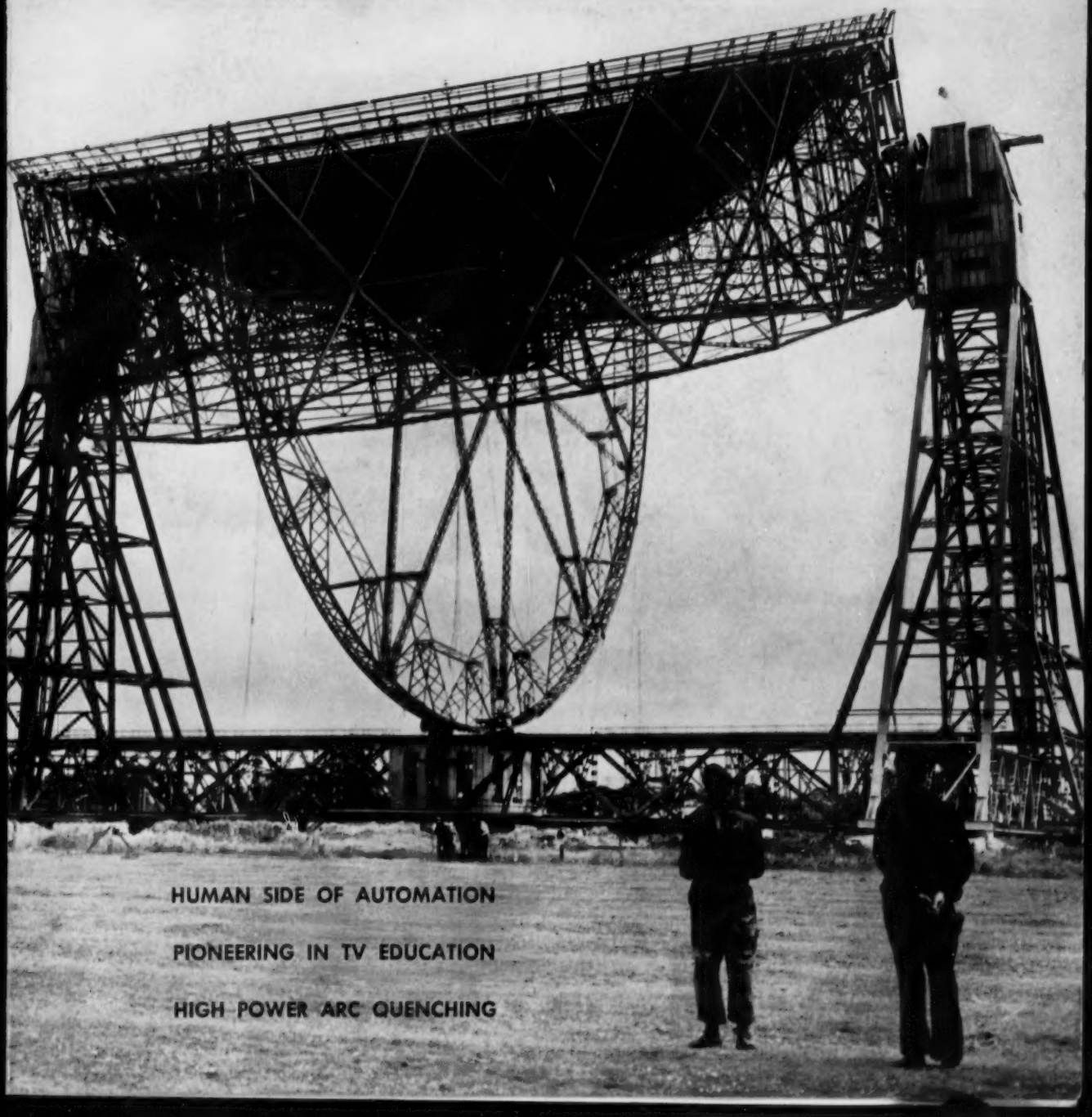
ELECTRICAL ENGINEERING

SEPTEMBER 1957

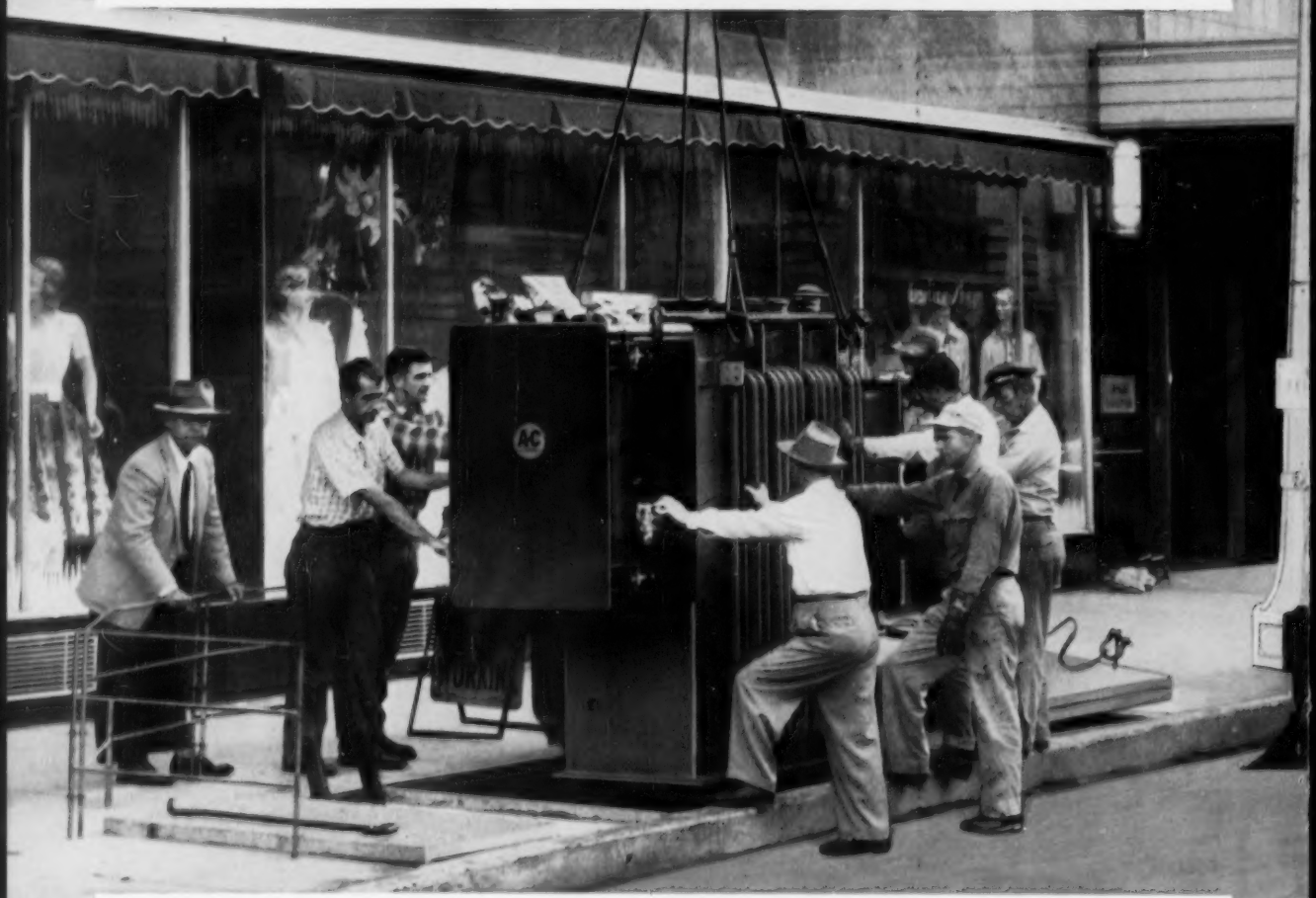


HUMAN SIDE OF AUTOMATION

PIONEERING IN TV EDUCATION

HIGH POWER ARC QUENCHING

Meeting Growing System Needs



Another Allis-Chalmers network transformer goes into service—solving a load concentration problem. Compact design, rugged construction, conveniently located accessories — features that mean maximum dependability and easy maintenance have made this unit the logical choice of utilities everywhere.

If you have a system load problem, skilled, experienced Allis-Chalmers engineers will help you or your consultants in working out a solution. Call your Allis-Chalmers representative, or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin, for further information.

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ELECTRICAL ENGINEERING

SEPTEMBER 1957
Vol. 76, No. 9

Published monthly by American Institute of Electrical Engineers

B. I. S. Photo

THE COVER: World's largest radio telescope tilted during test. The 250-foot instrument at Jodrell Bank was built for Manchester University for exploration of the skies by radio astronomy.

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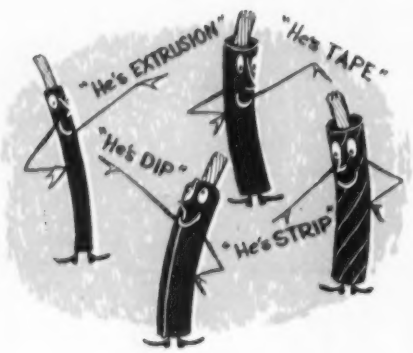
Hearken to this woeful fable of the man who bought a "bargain" cable

A. C. Current, a budding E. E.
Bought cables from many a source
But he didn't take time to consider, you see
That some last longer than others, of course.

For some circuits *any* insulation will do—
For others, just one type is proper
But Okonite he never consulted, we rue,
As to which one should cover his copper.

It seems Mr. Current mistakenly thought
(Indeed, 'twas a total delusion)
That Okonite cable would cost him a lot
Whether made by strip, tape, dip or extrusion

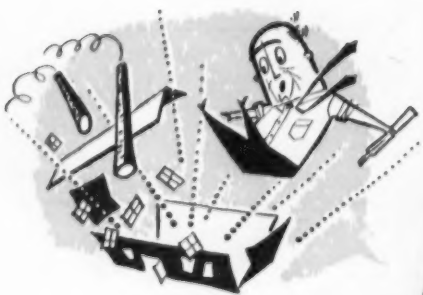


Only Okonite insulates cables *all* ways
So our prices are not always highest
And thus when you ask us what cable to use
Our recommendation's unbiased.

The price *does* differ, depending on methods
(The type insulation and how it's applied)
The proof of the pie is in service records . . .
Which we would have gladly supplied.

But A. C., in order to make things look good
Chose a cable he thought was a "buy"
It lasted, we hear, no more than a year,
Then blew him and his factory sky-high.

We hate to relate this horrible fable
But here is a moral for all:
If you should desire a superior cable
By extrusion or strip . . . by taping or dip
Just write us a letter, or call.



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where there's electrical power . . . there's **OKONITE CABLE**

4827

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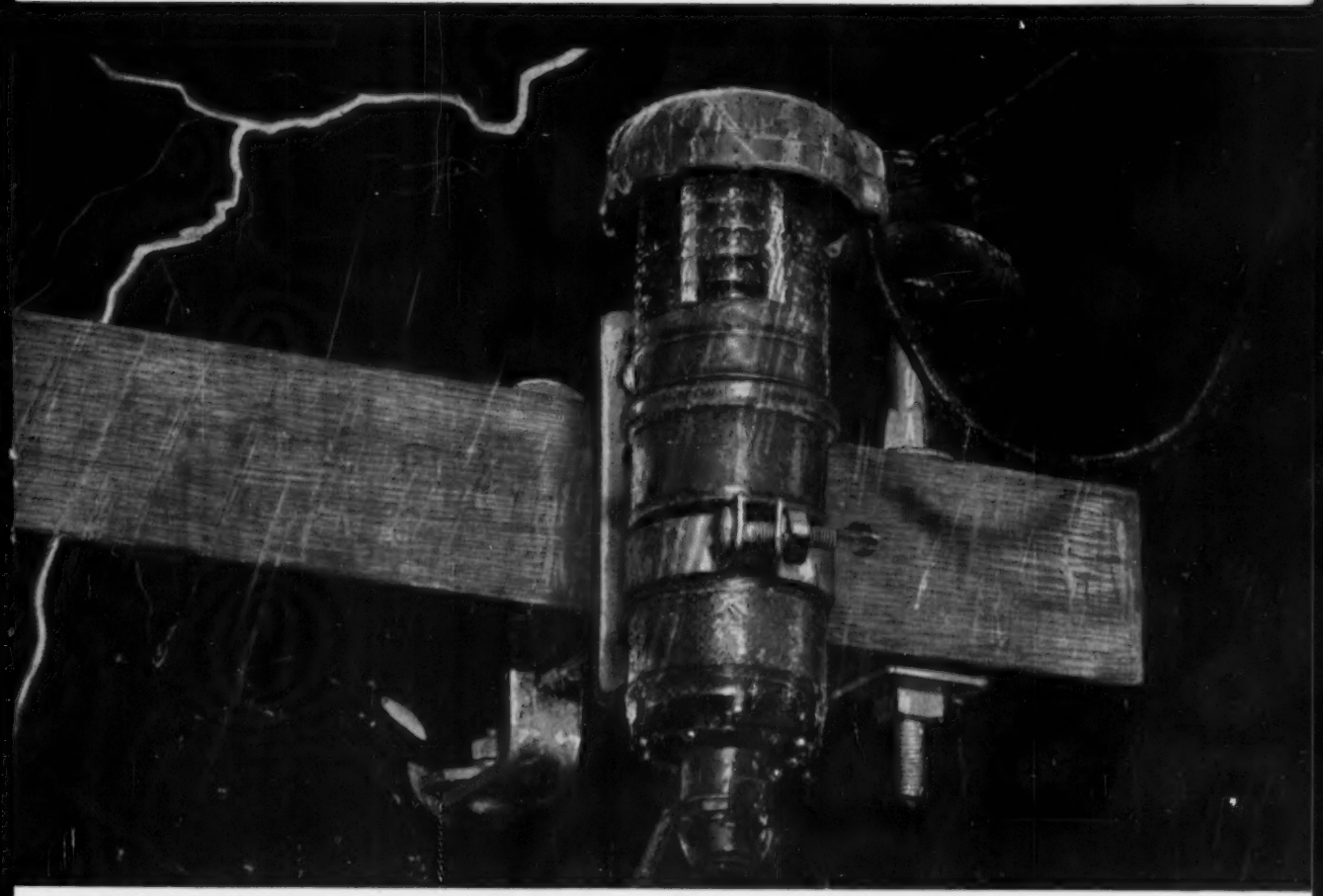


Why More Utilities Are Selecting L-M Type E Valve Arresters

L-M valve-type distribution lightning arresters have established an outstanding performance record by giving millions of service years of reliable protection. The Type E has been a leader in the field, and hundreds of thousands have been giving excellent service for many years. The failure rate is phenomenally low.

Here are some of the reasons for this remarkable record, and for the great increase in customer preference for the L-M Type E valve arrester.

Balanced Sparkover: Spark gap is a ladder-gap design, pre-set and then permanently sealed in the arrester housing. It cannot be knocked or burned out of adjustment. Gap is precision-made to assure optimum balance between 60-cycle sparkover and impulse sparkover.

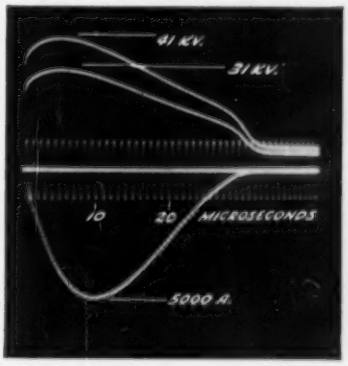
Low IR Drop: L-M now has a new Type E arrester, the E-3, which provides even lower IR drop than its popular predecessor. The new Type E-3 also provides greater durability and discharge capacity. These advantages are made possible because the new Type E-3 has an improved gap which provides greater 60-cycle interrupting ability, permitting reduction of the resistance of the valve element. The oscillogram shows the improvement in IR drop between the Type E and the new Type E-3.

Positive Protection: L-M valve arresters have a Pyrex glass housing which permits visual inspection of the spark gap in the field. Should the arrester become damaged, telltale evidence can be readily seen through the glass. If the arrester should fail to interrupt 60-cycle follow current for any reason whatsoever, L-M's patented Isolator provides positive assurance against grounding the feeder by disconnecting the ground lead from the arrester.

Other features include Zincilated (Zincilate No. 100) arrester housing clamp, fibre-glass cap, and fibre-form packaging. New packaging provides additional strength to the carton so arresters can be stacked easily on pallets.

Get Complete Information

Get the whole story of L-M arrester performance and application. Ask the L-M Field Engineer, or write for a copy of bulletin on the new Type E-3 arrester, to Line Material Industries, Milwaukee 1, Wisconsin.



Oscillogram shows reduction in discharge voltage in the new Type E-3 valve-type lightning arrester. Curves are for a 9 kv unit. IR drop has been reduced from 41 kv to 31 kv—a remarkable improvement in a unit that already has established an enviable performance record over many years' service.

LINE MATERIAL Industries

McGRAW-EDISON COMPANY

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2 TANTALUM CAPACITORS SERIES TW

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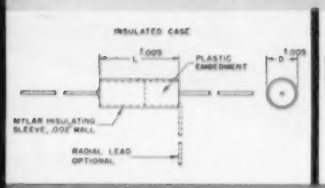
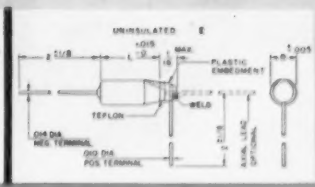
The new Series TW Ohmite subminiature Tan-O-Mite® TANTALUM CAPACITORS are wire-type units that feature greater capacitance per unit volume, lower leakage current and power factor, and small capacitance drop at extremely low temperatures as compared to other types of electrolytics. Ultrasmall for low-voltage DC transistorized electronic equipment, these new tantalum capacitors have *high stability, high capacitance, long shelf life,* and excellent performance under temperature extremes of −55° C to +85° C. They are available in six *subminiature sizes:* 0.1 to 60 mfd. over-all capacitance range.





SIZE	UNINSULATED		INSULATED	
	D (inches)	L (inches)	D	L
T	.075 (5/64)	.156 (5/32)	.082	.203
S	.075 (5/64)	.187 (3/16)	.082	.234
M	.095 (3/32)	.172 (11/64)	.100	.218
A	.095 (3/32)	.250 (1/4)	.100	.312
B	.125 (1/8)	.312 (5/16)	.134	.375
C	.125 (1/8)	.500 (1/2)	.134	.562

Smallest size is .075 (5/64) x .156 (5/32) inches; the largest is .125 (1/8) x .500 (1/2) inches. Five stock sizes are available in a wide range of capacitances, voltages. Units insulated with a tough Mylar® plastic sleeve can be furnished. *Write on company letterhead for Bulletin 148B.*

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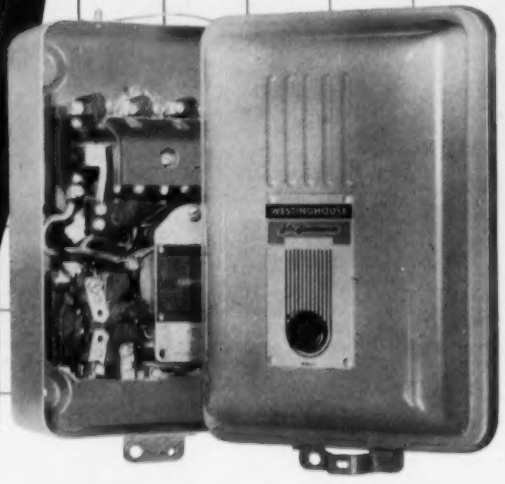

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NEMA SIZE	110 Volt				220 Volt				440-600 Volt			
	1ø		3ø		1ø		3ø		1ø		3ø	
	Old Rating	New Rating	Old Rating	New Rating	Old Rating	New Rating	Old Rating	New Rating	Old Rating	New Rating	Old Rating	New Rating
0	1	1	1½	2	1½	2	2	3	1½	3	3	5
1	1½	2	3	3	3	3	5	7½	5	5	7½	10

Westinghouse uprated starters give you: More horsepower — in eight new starter ratings. Less cost and space — in applications where the rerated size 0 starter replaces the size 1 starter, and the size 1 replaces the size 2.

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case – molded phenolic, metal
size (inches) – 1½, 2½, 3, 3½, 4½, 4¾
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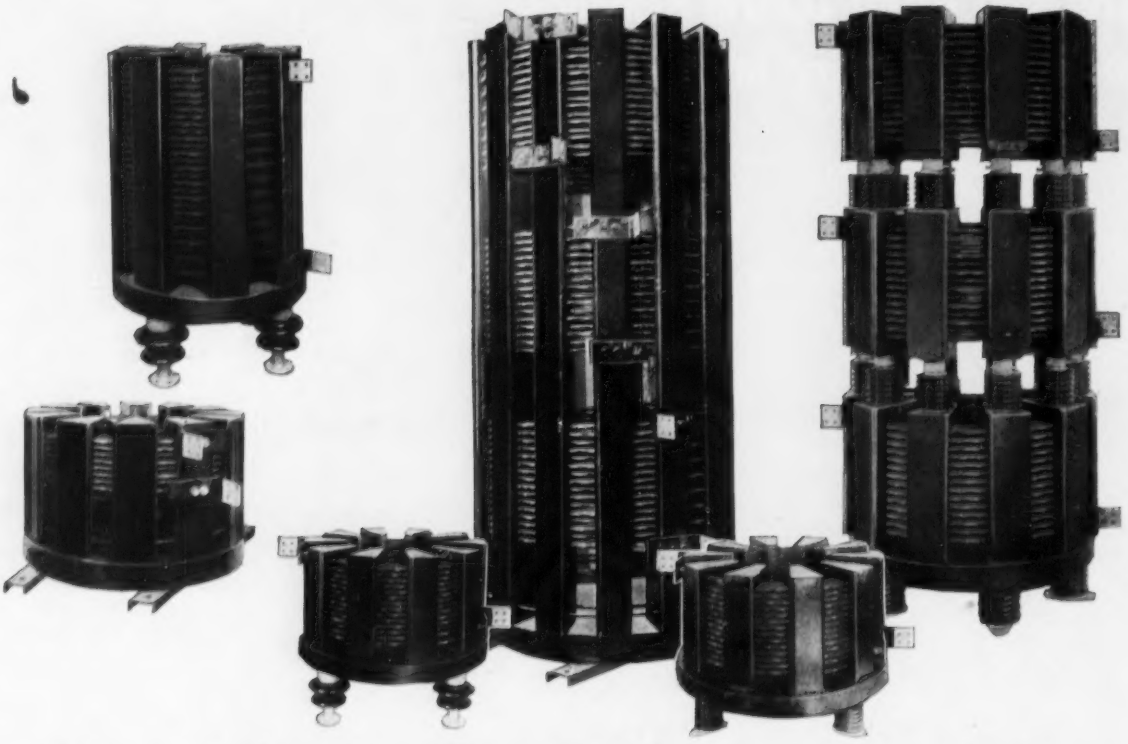

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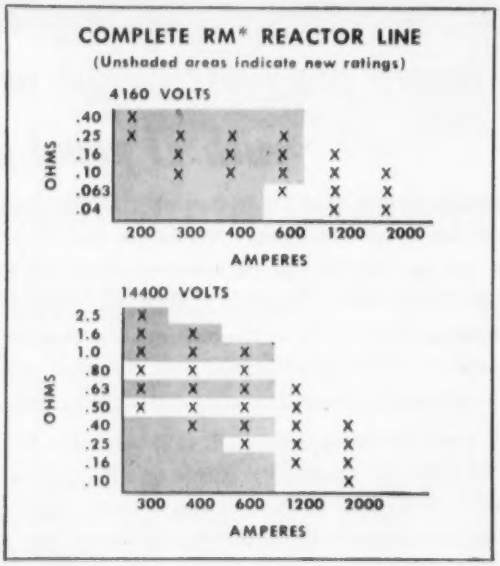
*Repetitive Manufacture



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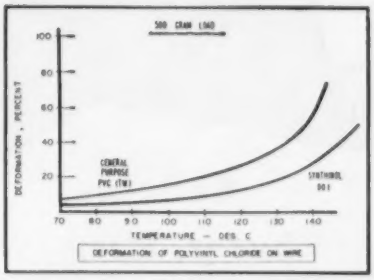
An unusual polyvinyl chloride compound

CURRENT TRENDS

No. 10 in a series of articles

Polyvinyl chloride (PVC) compounds have been widely used in the wire and cable industry. These compounds have many useful properties and have found wide application as insulations and sheaths. These properties and applications were discussed in Current Trends No. 4, entitled "Progress Report on Polyvinyl Chloride Insulations." Like most materials, the conventional PVC compounds have limitations, and there are many applications where these weaknesses have prevented taking full advantage of the good features. This discussion is about a special PVC compound, which was designed and developed in an effort to incorporate into a single compound as many desirable properties as possible. Known as Synthinol 901, this compound was developed in the laboratories of the Rome Cable Corporation, Rome, New York. Today Synthinol 901 is being used as insulation and sheath for wires and cables in many applications where conditions of installation or use require properties not to be found in conventional PVC compounds.



Graph shows heat deformation vs. temperature, and compares Synthinol 901 with conventional Type TW compounds. Test run in accordance with Underwriters' Laboratories standard procedure, except for temperature.

Shortly after World War II, the Underwriters' Laboratories established the need for a PVC insulated wire suitable for wiring appliances where an operating temperature rating of 105 C was required. Rome Cable laboratory attacked the problem of developing a PVC compound to meet U/L requirements. The laboratory was also given a list of desired additional properties for incorporation into this compound. This project assignment was completed in 1949, at which time Rome Cable introduced Synthinol 901. Since 1949 this compound has provided the solution to a rather impressive list of tough wiring problems.

True, there are many 105 C PVC compounds available today; there are likewise compounds available which possess one or more of the individual properties on the list describing Synthinol 901. What is unusual is that here, for the first time, was a single PVC compound which possessed all of these superior properties and which also retained all of the properties found in conventional PVC materials.

Rather than presenting data and charts, it is believed that the practical value of this compound is better illustrated by relating a few of the concrete results of eight years of continuous work with users who have had difficult problems. These case histories are all a matter of record.

1. Oil refinery, industrial and chemical plant wiring.

Plant and oil refinery engineers had long used Type TW for plant wiring. Results were good, but too often the heat deformation characteristics of conventional TW caused trouble in warm locations. Since one of the outstanding properties of Synthinol 901 was its superior resistance to deformation, this material was tried, and soon became widely used because of its much better record in service. During several years of experience Synthinol 901 proved to have chemical and solvent resistance so superior to conventional materials that it came into wide use where this resistance was needed. In these industrial applications, which are not under the jurisdiction of the National Electrical Code, the higher temperature ratings have made possible appreciably higher current carrying capacities, with consequent savings.

In chemical plant wiring the corrosive action of chemicals and solvents has always been a tough problem. Although PVC has inherently better resistance to chemicals and solvents than many other materials, engineers desired further improvement. One user ran a series of long time tests with samples immersed in various solvents, acids, and alkalis. The results clearly showed that Synthinol 901 would give longer life than other PVC compounds, when exposed to these chemicals.

2. Oil-filled transformers.

Transformer engineers have long been searching for a cable construction to replace the varnished cambric-insulated cable used for high voltage and tap changer leads in oil-filled transformers. One transformer manufacturer, encouraged by successful experience with Synthinol 901 in other applications, began a comprehensive study of this insulation in lieu of VC on these high voltage leads. In operation these leads are immersed in the transformer oil at elevated temperatures. This test program extended over several years, and included evaluation of almost every conceivable effect of Synthinol 901 on the life and performance of the transformer. These engineers came up with the following reasons for standardizing on Synthinol 901 for this application:

1. There was less sludge in the oil than when VC insulation was used.
2. There was no harmful degradation of electrical properties of the oil.
3. Conductors ran cooler when insulated with Synthinol 901, permitting a 7% increase in current rating of the lead cables.
4. The use of Synthinol 901 in lieu of VC afforded substantial dollar savings.

3. Coil Leads.

Many manufacturers of small coils for use in electrical and electronic components had tried for years to use PVC insulated lead wires in their manufacturing operations. These coils, with leads attached, are put through a varnish or wax impregnation followed by a baking cycle. The baking cycles may be as long as 16 hours at temperatures as high as 105 C. In a great many of these cases PVC insulated lead wires had given trouble due to shrinkage, cracking, and stiffening during the impregnation and subsequent baking. Here is an application where Synthinol 901 has been doing an almost faultless job. After nearly eight years of wide usage, there has been no case of shrinkage, cracking, or stiffening of insulation reported where Synthinol 901 has been used in this application.

4. Panelboard wiring.

For many years panelboards and switchboards have been wired with Type TA wire. This wire has a layer of asbestos over a primary insulation of PVC. The asbestos has been used as a protection against the heat deformation which was known to occur at sharp bends and points where wiring was held under clamps. Transformer and machine tool manufacturers have found that the superior resistance of Synthinol 901 makes the asbestos covering unnecessary. In this application, for additional safety, the insulation thickness is normally $\frac{1}{64}$" heavier than standard. These manufacturers have found Synthinol 901 to be an economical solution to their particular needs.

These case histories are only a few of the applications where this unusual compound has served well. Synthinol 901 has been proven by test and actual use to be superior to conventional PVC compounds in the following ways:

1. Suitable for continuous operation at higher temperatures.
2. More stable under severe heat cycling.
3. Suitable for continuous immersion in hot transformer oil.
4. Superior resistance to chemicals and solvents.
5. Greater resistance to heat deformation.

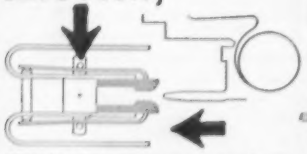
All of our experience and knowledge in this field is available to you. If you have a wire and cable problem where you think Synthinol 901 might prove useful, why not let us help you?

ROME CABLE CORPORATION, Rome, New York

NEW! Revolutionary S&C Contact Cuts Cost of Switch Maintenance!

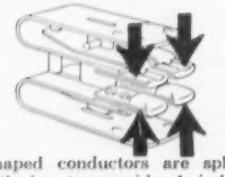
4-Point Advantage

SLIPS e-a-s-i-l-y



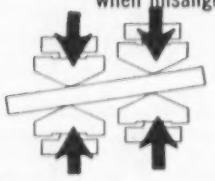
Tension bar and spacer prestresses contacts and reduces necessary force required to close contacts (effort at switch handle). Narrow convex silver-clad contact surfaces plow away any dirt from silver-nickel insert on blade tongue.

GRIPS at 4 points... not 2



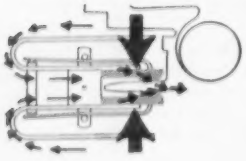
U-shaped conductors are split lengthwise to provide 4 independently sprung contact fingers. The pressure is applied to each by a flat beryllium copper loading spring.

GRIPS at 4 points... even when misaligned



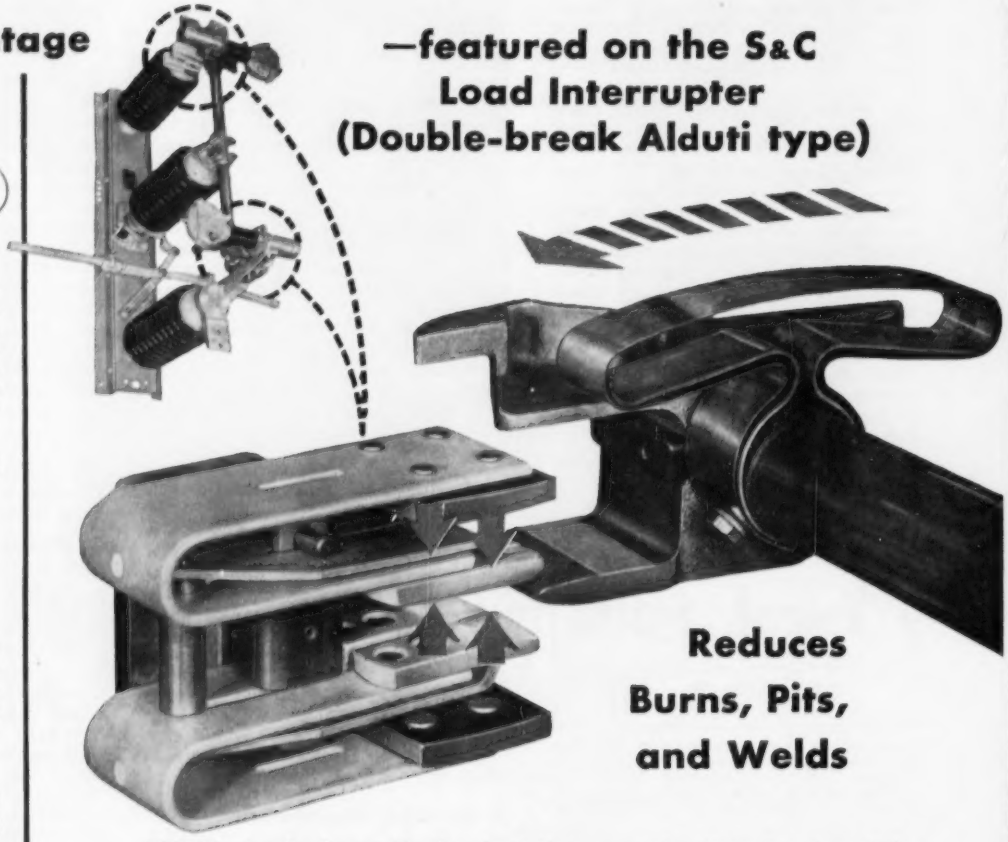
For 2 reasons: (1) Pressure is applied independently by springs in 3-point suspension which can rock and roll; and (2) pressure is applied equally on either side of blade by tension bar.

GRIPS harder... but only when needed



The reverse loop construction provides a magnetic field pattern during short-circuit current flow that causes repulsion and attraction forces to combine to produce heavier contact pressure when you need it.

—featured on the S&C Load Interrupter (Double-break Alduti type)



Reduces Burns, Pits, and Welds

NEMA standards specify the short-time current ratings for air switches and interrupter switches. And it is natural that equipment can be built to meet these requirements when new.

The big "if" is what happens in service.

You have found from experience that switches with conventional contacts must be carefully installed, and then continually maintained if they are to retain their original NEMA short-time ratings. As a practical matter such equipment generally gets little maintenance, and the short-time current capacity falls off.

You want a contact that meets NEMA standards after being in service, in spite of some misalignment in installation, and in spite of little maintenance. The Double-break Alduti has such a contact.

No more expensive contact maintenance work in the shop, dressing off burns and pits. No more worry about contacts welded shut after a momentary short-circuit loading. And the magneto-motive effect through the U-shaped contacts provides extra contact pressure when it is needed.

Specialists in High-Voltage Circuit Interruption Since 1910

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POWER FUSES • DISTRIBUTION CUTOUTS AND FUSE LINKS • LOAD INTERRUPTERS • METALCLAD SWITCHGEAR

Expanded line of stock Sola transformers regulate filament loads up to 25 amperes

Sola Constant Voltage Filament Transformers are now available *from stock* in six different output ratings from 2.4 to 25 amperes. Now, even sizable banks of electron tubes may be supplied from one compact source of ±1% regulated filament voltage.

Because of the current-limiting characteristics of Sola transformer design, cold filament inrush current is restricted to a safe level at loadings within 75-100% of the transformer's full-load current rating.

The static-magnetic Sola filament transformer, furnished with separate capacitors, is designed for simple mounting as a component of manufacturers' products. The dependable tube performance and longer filament life these units offer is available at only a moderate increase in cost over conventional filament transformers.

For further information and specifications, contact your Sola representative, or write for Circular CVF-269.

SOLA *Constant Voltage* **TRANSFORMERS**

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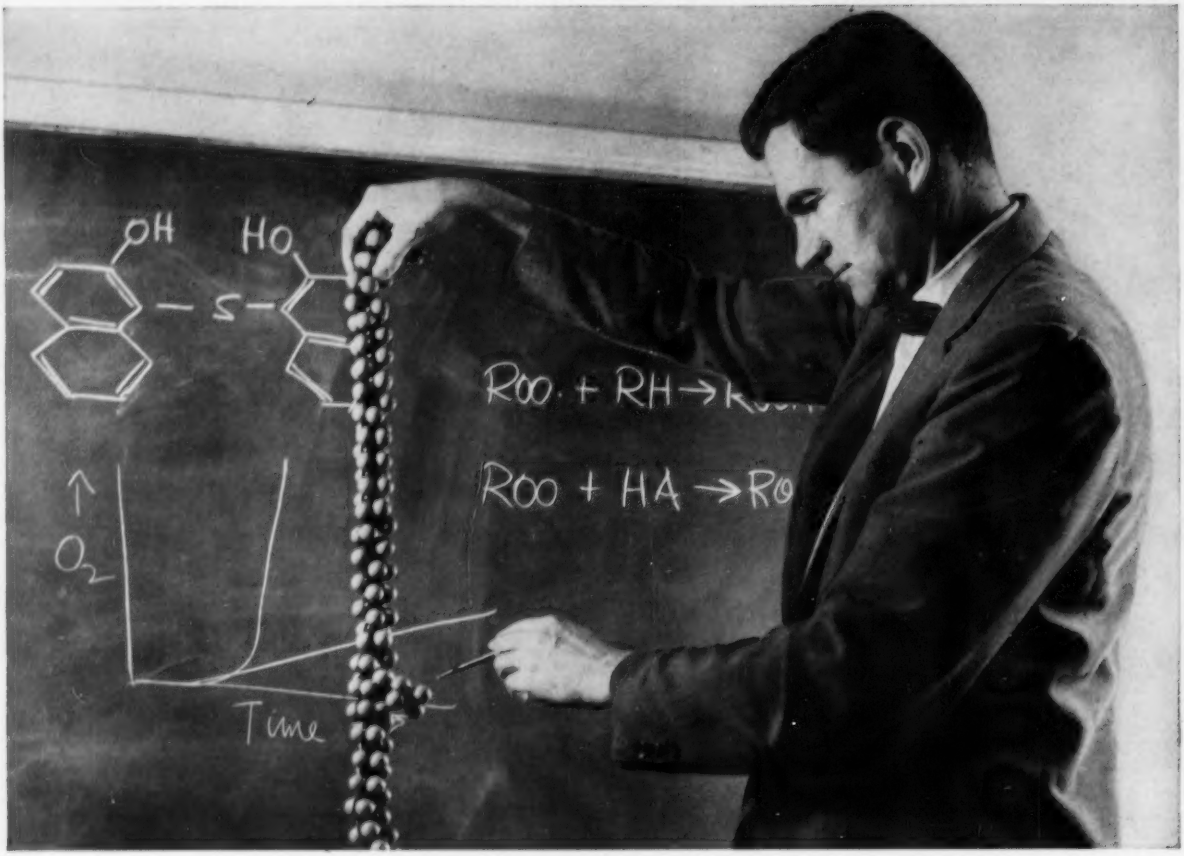

Bell Laboratories chemist Field H. Winslow, Ph.D., Cornell University, with a scale model of a small section of a polyethylene molecule. Branch formation indicated by pencil is vulnerable to oxidation. Dr. Winslow and his associates worked out a simple way to protect long polyethylene molecules needed for durable cable sheathing.

THE DILEMMA OF GIANT MOLECULES

Solution: 2 plus 2 equals 5

Polyethylene is used to protect thousands of miles of telephone cables. It is tough, light and long lasting. Its strength lies in its giant molecules—a thousand times bigger, for example, than those of its brittle chemical cousin, paraffin wax.

But polyethylene has a powerful enemy: oxidation, energized by light and heat, shatters its huge molecules to pieces. This enemy had to be conquered if polyethylene was to meet the rigorous demands of cable sheathing. Paradoxically, it was done by making the whole better than the sum of its parts—just as though 2 plus 2 could be made to add up to 5.

To check the ravages of light, Bell Laboratories chemists devised the simple yet highly effective remedy of adding a tiny dose of carbon black. Then antioxidants, such as those commonly used to protect rubber, were added to check attack by heat. But here the chemists encountered a dilemma: although the carbon black protected against the effects of light, it critically weakened the effectiveness of the antioxidants.

To solve this dilemma, Bell Labs chemists developed entirely new types of antioxidants—compounds not weakened by carbon black but which, intriguingly, are very much more effective when carbon black is present. The new antioxidants, plus carbon black, in partnership, provide long-lasting cable sheath—another example of how research at Bell Telephone Laboratories works to improve your telephone service.

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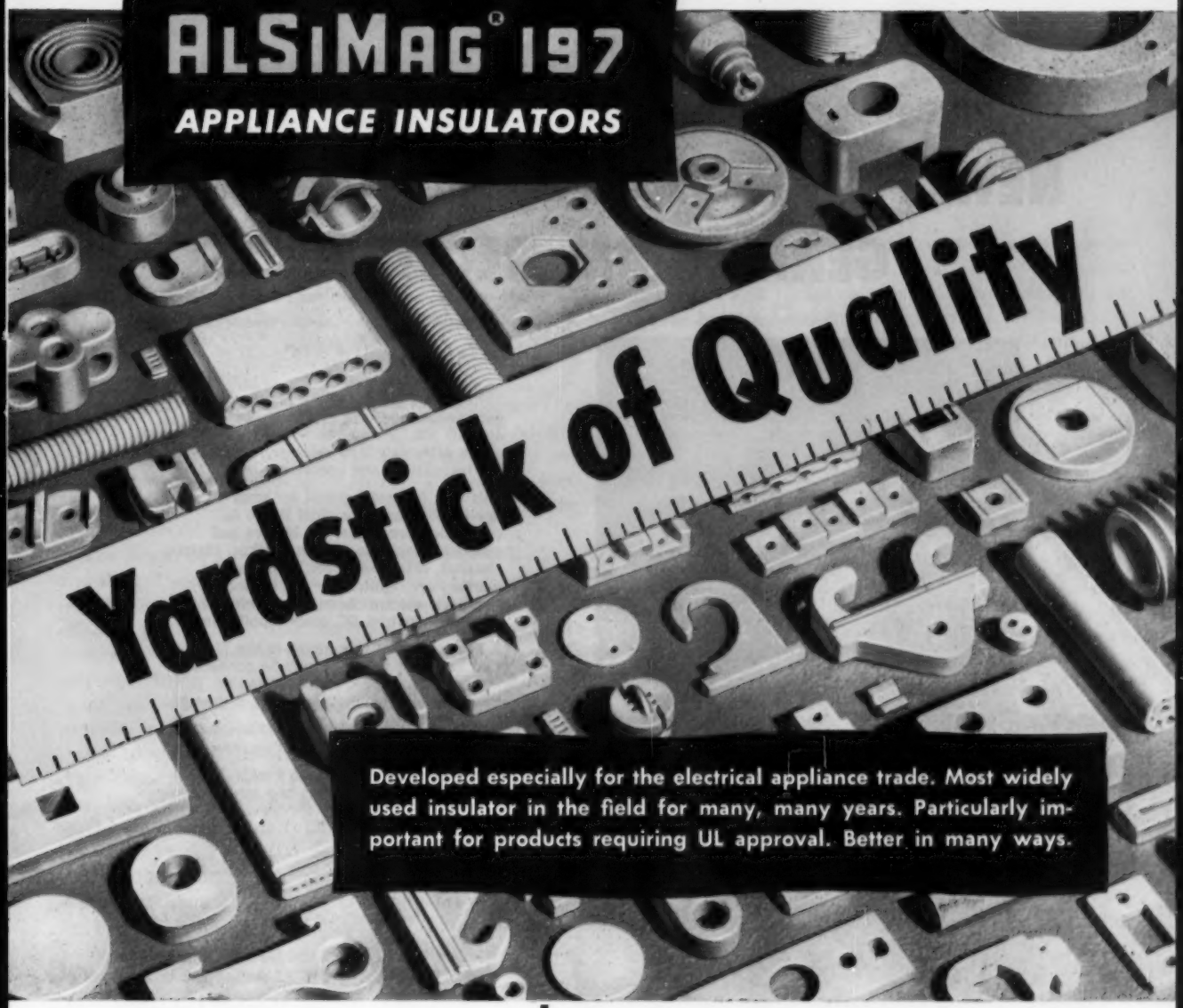
WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

AlSiMag® 197

APPLIANCE INSULATORS



Developed especially for the electrical appliance trade. Most widely used insulator in the field for many, many years. Particularly important for products requiring UL approval. Better in many ways.

- superior insulating resistance at elevated temperatures
- low electrical leakage . . . prevents electrical shocks in use
- superior resistance to repeated thermal shock
- well vitrified . . . low moisture absorption
- long life . . . will not soften, char, or deteriorate
- strong, uniform parts for faster assembly . . . dimensionally accurate . . . resist chipping and breaking.

Your future sales depend on customer satisfaction. Safeguard the performance and reputation of your product with safe, uniform AlSiMag 197 insulators . . . available at reasonable cost in quantity desired. Fast shipments.

For — Oven Bushings . . . Iron Blocks . . . Toaster Hooks . . . Element Supports . . . Element Spacers . . . Winding Forms . . . Automotive Parts . . . Dryer Insulators . . . Many Similar Applications.

Send blueprint or sketch for complete information on AlSiMag 197 parts for your use.

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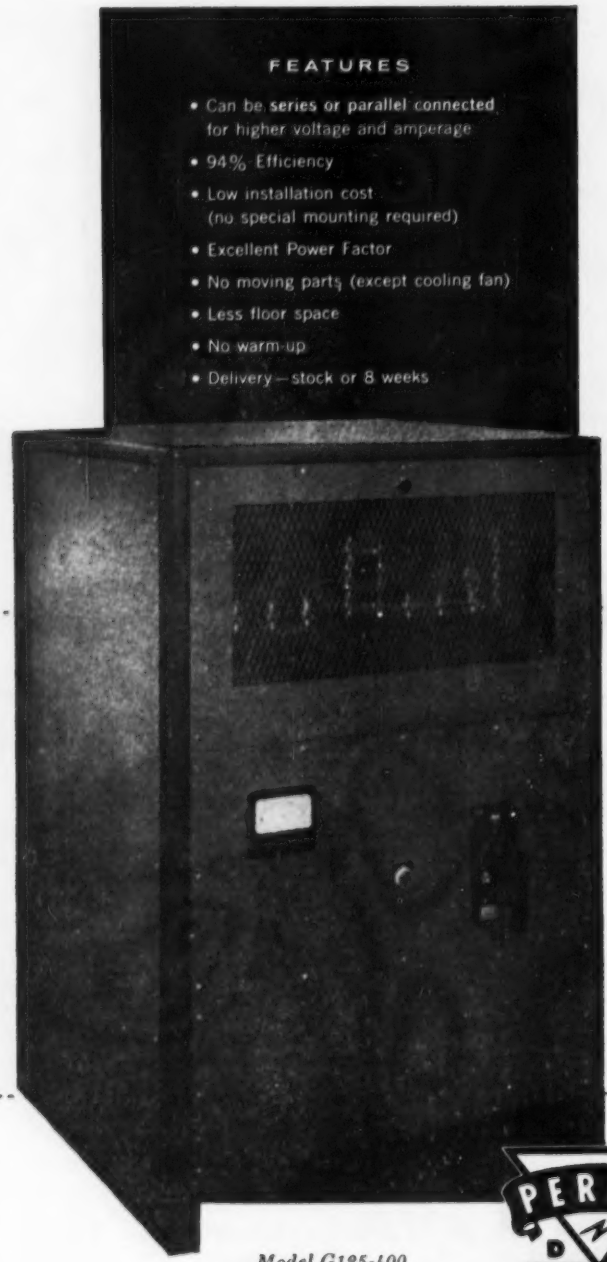
For DC Power Applications...

NEW PERKIN 50 KW Standard GERMANIUM RECTIFIER UNIT


FEATURES
• Can be series or parallel connected for higher voltage and amperage
• 94% Efficiency
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• No moving parts (except cooling fan)
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Model G125-400
50 KW Germanium
Rectifier Unit

Through the unique characteristics of germanium, the new Perkin Model G125-400 50 KW Germanium Power Unit offers extremely high efficiency and a low installation and operating cost.

This unit is ideally suited for such applications as: Municipal DC to AC conversion programs, DC Motors and controls, magnetic devices, brakes, chucks, clutches, lifting magnets, in place of mercury-arc, ignitron or mechanical rectifiers, electro-chemical and other general industrial DC power applications.

A key feature of this model is the fact that two or more units may be connected in series or parallel and operated at one time for higher voltage and amperage.

Perkin also manufactures other heavy duty rectifier units (selenium and germanium).

Send your specifications to Perkin for prompt recommendations and quotations.

SPECIFICATIONS:

A.C. INPUT:	230/460 V., 60 Cycle, 3 Phase
D.C. OUTPUT:	115-125 Volts @ 400 Amperes *Available also connected for 62.5 V. @ 800 Amperes*
CONTROL:	Air Circuit Breaker
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RIPPLE:	5% RMS
EFFICIENCY:	94%
POWER FACTOR:	95%
COOLING:	Forced Air Cooling
METERS:	Ammeter
WEIGHT:	1200 Lbs. *Approx.*
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Pioneering in Television Education

J. R. BRUGGER

The potentialities of closed-circuit television in the field of instruction are pointed out in this description of an experiment now being conducted in Maryland's Washington County school system.

TELEVISION, one of today's most important developments, perhaps is to society what atomic energy is to civilization. Indeed, each exerts a tremendous force on our way of living. This article indicates some of the potentialities television offers in the area of instruction.

The Board of Education of Washington County, Md., and its staff were planning a new senior high school and felt any new construction should include facilities for the effective use of radio and television. They investigated designs in an attempt to determine what to install in the way of lighting conduits, duct work, flexible classroom space and other mechanical considerations in order to provide for future developments. These inquiries, directed to building construction consultants, educational consultants, manufacturers, television groups, and agencies interested in the advancement of education, served the purpose of securing information and indicated local interest in the use of television for instruction. The members of the Board of Education learned much about developments in televised instruction and became very interested in including facilities for its installation in new buildings. As a result of these investigations, the county became one of a number of school systems planning to make some use of television for instructional purposes. Numerous experiments were being conducted throughout the country to test the effectiveness of television as an instructional device. It was evident that the results, while fragmentary and incomplete, indicated that the potentials of televised instruction were tremendous.

It was then that the professional organization of the electronics industry, the Radio-Electronics-Television Manufacturers Association (RETMA), and The Fund for the Advancement of Education (FAE) decided to unite in sponsoring a comprehensive project to study the ways of using television for instructional purposes, to determine the contributions offered by television in improving instruction in educational systems and to evaluate the results. It was decided to offer the opportunity of making such a study to a typical school system. A school system was to be selected which (1) was not too large or too small; (2) included urban and rural areas with manufacturing, general businesses, and farming; (3) operated kindergarten and junior college; (4) was developing an adequate building construction program; (5) had done some work in curriculum development; and (6) had enlisted the interest and support of parents and citizens in the education program. The Board of Education of Washington County deemed itself fortunate to be able to submit a proposal of what would be included if given the opportunity to develop such a project.

The proposal for developing a closed-circuit television project was accepted by the joint sponsors on May 24, 1956. The project was officially approved by the entire RETMA organization at their annual meeting in Chicago in June 1956, at which time appropriate resolutions were adapted. The proposal was broad in scope and general in nature with the idea that it would be implemented and organized as a continuing project through planning with school personnel and interested citizens of the community. The 5-year project, with the support of FAE, United States Office of Education, Joint Council on Educational Television, Chesapeake and Potomac Telephone Company, RETMA, and other voluntary groups, was proposed under the direct control of the Board of Education of Washington County.

The formal proposal follows:

> The Board of Education of Washington County is interested in making a thorough study of the ways closed-circuit television may be used by a public school system as an integral part of the regular program of instruction and in making an evaluation of the various methods that are developed. It is proposed that the project will be carried on over a period of five years beginning September 1956, in the following areas:
>
> 1. Direct instruction of pupils in the basic subject matter offerings of the curriculum.
> 2. Supplemental motivation and enrichment of the program wherever feasible.
> 3. Extension of the in-service training program of teachers.
> 4. Interpretation of the school program to the public.
> 5. Improvement in the quality of the school program.
>
> Data will be gathered to evaluate the effectiveness of television in meeting such current educational problems as:
>
> 1. The enhancing of the status of teaching.
> 2. The relation of pupil-teacher ratio to the quality of instruction.
> 3. The continuation of rapidly increasing enrollments.
> 4. The lack of adequate classroom space.
> 5. The shortage of properly trained and certified teachers.
> 6. The organization of the school system to effect savings in personnel.
> 7. The distribution of the finances available for the school program.
> 8. The greater use of school, community and county resources.

Emphasis has been placed on developing ways that

Essentially full text of conference paper CP57-667, presented at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Recommended for publication by the AIEE Committee on Television and Aural Broadcasting Systems.

J. R. Brugger is with the Board of Education, Hagerstown, Md.

Fig. 1. Studio A control in foreground, film chain in background.

closed-circuit television may be used under normal conditions. Records are being kept and continually evaluated. During the initial operation of the project, exploration and experimentation have suggested appropriate tests, measurements, and research phases of the program. Theoretically, the developmental and experimental phases commenced with a ratio of approximately 85% developmental, 15% experimental in September 1956, and gradually will vary to about 15% developmental and 85% experimental by the end of the 5-year period.

Early in the summer of 1956 the committee chairman of the RETMA group interviewed a number of applicants for the position of chief engineer and, in turn, recommendations were rendered to the Board of Education of Washington County.

Inasmuch as the Board of Education of Washington County and its staff had outlined the general framework for organizing the project, a steering committee made up of a cross-section of school and community groups was appointed to develop plans for initiating the work. Its membership included representatives from the Board of Education, State Teachers Colleges, and the County Council of Parents and Teachers. The group showed a keen interest in the project from the start. Several days were spent in discussing ideas about the possibilities of using television for instruction. As a result, many ideas were developed which would orient teachers to the possibilities of televised instruction and provide an opportunity for planning the details of the program.

WORKSHOP

More than 50 teachers, principals, supervisors, and P. T. A. (Parent-Teachers Association) leaders, representing various subject matter areas and geographical regions of the county participated in the workshop which was held from July 9 to August 17, 1956. This proved to be a stimulating experience for all the participants. The members first organized into small groups to discuss what they thought could and could not be done by televised instruction. Problems and plans were studied and attempts made to meet the criticisms and objections raised when new approaches to traditional concepts were considered. Consultants experienced in television training and public school teachers experienced in television teaching presented their opinions to the group.

As a result of the discussions, the members of the workshop found they were actually re-evaluating their ideas about education and the learning process. It seemed reassuring to them to realize they were primarily discussing education rather than television. Television was viewed as a means to an end with the plans for the educational aspects of the program taking first place. Television, thus, became a vehicle for looking anew at educational problems, procedures, methods, theories, and techniques. This experience was most beneficial to the participants, and they expressed their continued interest and enthusiasm.

The learning process was analyzed in detail and the various items involved were studied. The question then arose as to which items could probably be handled readily by direct televised instruction and which ones would be difficult or impossible to attain.

This analysis led to the idea of organizing a teaching team with the television teacher responsible for the items that television can do best, and a classroom teacher caring for those which, at the moment, seemed to be better handled by direct contact with pupils.

The lesson plans were therefore developed by the teaching team and regular meetings were scheduled throughout the school year for further planning and evaluation. A feed-back sheet for the classroom teacher was devised to aid in evaluating the television lesson.

Because the classroom teacher deals mainly with class organization and the personal problems of the pupils, it was felt a larger number of pupils might be grouped in the classrooms. It was decided, therefore, to vary the class size and note the results.

The last 10 days of the workshop were spent in using simple vidicon equipment for the presentation of sample lessons. Each lesson was followed with an evaluation session and, in a number of cases, the lessons were retaught using the suggestions that had been made.

Outlines of the general framework of the lessons were developed for each instructional area to be included in the television program. Classroom and television teachers worked together in preparing guide material to be used in their joint handling of the lessons. It was agreed to expand this material at the team meetings during the year in keeping with pupil interests and the revisions suggested by the teachers.

Direct instruction for the September 1956–June 1957 school term included the following:

Advanced English
General Senior English
United States History: Grade 11
Geometry: Grade 10
General Science: Grade 9
Science: Grade 6
Arithmetic: Grade 5
Social Studies: Grade 4
Music: Grades 4, 5, and 6
Art: Grades 1, 2, and 3
Art: Grades 4, 5, and 6

Reading Experiences: Grades 1 and 2
Number Experiences: Grades 2 and 3

OPERATION

TELECASTING to two high schools began on September 11, 1956, by the use of temporary mobile equipment. The six elementary schools' instructional program was initiated on November 15, 1956, for grades 4, 5, and 6 and the primary program for grades 1, 2, and 3 on December 17, 1956, totaling 6,000 students, employing as many as three channels simultaneously.

To the present, all telecasting has originated at the Television Center of the Board of Education. It is possible, however, to originate telecasts from the North Hagerstown High School, South Hagerstown High School, the Washington County Museum of Fine Arts, and the Washington County Free Library. To accomplish this schedule, several technical considerations had to be determined. These were influenced, in part, by equipment which was currently available from manufacturers and, in part, by the anticipated operating techniques to be employed. The first duty of the chief engineer was to make these decisions.

In considering the service to be rendered to the eight schools in the original program and the teachers' most effective method of presentation, it seemed mandatory to adopt, in the main, broadcast television studio techniques. In further discussion of the various aspects of the operation, it was mutually agreed by the representatives of RETMA, Chesapeake and Potomac Telephone Company, and the Board of Education that the areas of responsibilities would be defined as follows:

1. The Board of Education would originate standard broadcast video and audio signals using conventional 75-ohm 1.4-volt peak-to-peak video and 500-ohm 6-milliwatt audio, and feed these to the Chesapeake and Potomac Telephone Company.

2. The Chesapeake and Potomac Telephone Company would modulate three low-power very high frequency (vhf) transmitters with the video and audio signals supplied, and distribute the vhf radio-frequency signals by coaxial cable to the schools in the program.

3. The Board of Education would amplify and distribute the vhf radio-frequency signals to the classrooms in the schools.

4. Telecasts would be viewed in the classrooms on standard vhf broadcast receivers.

5. Equipment involved in the foregoing points 1, 3, and 4 would be supplied by RETMA and other members of the industry.

After considering the various factors involved, a common synchronizing (sync) generator was installed for all the studios' equipment. As additional studios are equipped, this practice will be continued.

A conventional broadcast-type audio console was employed at each control. Facilities for multiple microphones were available. Standard broadcast practices were used throughout the audio system. Both boom and lapel microphone techniques were used as situations required. Automatic level control audio amplifiers are employed. Turntables and tape recorders supplemented audio operations. The control position included facilities which enabled the producer to address cameramen, floor assistants, and talent at appropriate times. Normally, this signal was fed on headphones. During rehearsal and other than "air" operations, a speaker in the studio was energized to allow two-way communication. The size of each of the two studios which carried most of the programs was approximately 700 square feet. This area was found to be a bare minimum. (From experience of the past year, it would seem desirable to double the studio size, utilizing two walls of the studio for set props. With this procedure, programs could be telecast continuously from one studio area. This would allow one set to be arranged while the other is on telecast. Such an operation offers some hazards because of movement of props, etc., but full utility of the equipment results. Needless to say, the lighting requirements would be installed to accommodate such an operation.)

Fig. 2. Studio B, showing 6th grade science lecture.

Three studios were used for the operation, two of which employed industrial-type cameras. These had a single lens and no viewfinders, and were used with a relative degree of satisfaction, but left much to be desired. In order to utilize vidicon equipment fully in this type of operation, the following requirements are mandatory:

1. Waveform monitors for evaluating the picture information for each camera.

2. External sync drive (vertical, horizontal, and blanking) with variable controls in the camera control unit. Blanking control should be readily available at operating position.

3. Video gain control on camera control unit.

4. Picture monitor in conjunction with the waveform monitor on camera control unit.

5. Electric focus control readily available at operating position.

6. Standard RETMA sync generator.

7. Circuit for clipping sync out of camera output.

8. Switcher capable of switching composite and non-composite video.

9. Circuit for adding sync at the switcher output.

10. View finder and multiple lens mount or equivalent on camera.
11. Mechanical focus on camera.
12. Tally light on camera.
13. Camera mounted on tripod with dolly and friction head.
14. Intercommunication facilities.

The equipment in one studio included all of these requirements. It is hoped all equipment in use commencing with the 1957 fall school term will be so equipped.

STAFF

Two FULL-TIME ENGINEERS were employed along with two producers to operate the program. Twelve teachers devoted their entire time in preparation and presentation of lessons by television. Two teachers devoted part of their time to studio teaching. Junior college students served as cameramen, floor managers and general production helpers.

LIGHTING

STUDIO LIGHTING was also provided by RETMA and members of industry. Generally, typical television practices were used. The basic lighting problem in educational application lies somewhere between that used in industrial closed-circuit television and that in commercial broadcast television. The industrial installation is usually a fixed arrangement calculated to supply the necessary scene illumination with a reasonable range of brightness contrast. The commercial studio must possess great flexibility in order to achieve the maximum artistic effects that light can supply, with comparatively little regard to the complexity or cost of the lighting system. The problem was to produce a lighting system which was better than merely basic, which possessed a reasonable degree of flexibility, and which could be installed and operated by a school system at as low a cost as is practical.

In two studios, light was supplied by commercial fixtures designed for studio applications. Open studio floodlights or scoops, using 1,000- and 1,500-watt inside white lamps supplied the fill light required for basic illumination; their size and location permitted the reduction of heavy shadows to a minimum. Fresnel-lens spotlights in various sizes provided key or modeling illumination and also an amount of back lighting. These features helped show the form of three-dimensional objects and separated foreground objects from their backgrounds. With scene illumination levels in the 100- to 200-footcandle range, the radiant heat from these filament lamp fixtures was significant, resulting in some complaints by the studio teachers.

In the third studio, banks of fluorescent lamps in studio-type reflectors provided the basic illumination. These were supplemented by spotlights. The replacement of the majority of the filament illumination with fluorescent reduces the radiant heat in the teaching areas without adversely affecting picture quality. Also, the lower wattage consumed by the fluorescent units tend to produce slightly lower operating costs.

Additional studios being planned will utilize general fluorescent lighting. Large area, low-brightness luminous ceilings are capable of providing high illumination levels with minimum heat problems. Also, the nature of the lighting will be such that illumination at all points in the studio will be nearly the same. Necessary spotlighting for modeling and back lighting will be supplied by lamps with integral reflectors. These lamps will result in low equipment costs, and they may be easily aimed at specific scene areas. The over-all objective in this scheme is to provide the studios with a maximum usable teaching area for more and larger visual aids without requiring the moving and aiming of lighting equipment during a teaching period. It will also offer the opportunity to compare costs and effects of a more or less fixed general lighting system with the existing installation of studio-type equipment. This will afford installations of various combinations of lighting and may suggest comparisons of effectiveness, purchase costs, and operating costs.

EXPANSION

WITH THE OPENING of the school term, September 1957, the following operation is planned:

1. Six thousand square feet of operating area in addi-

Fig. 3 (*left*). Studio A, showing demonstration of number experiences for lower elementary grades. Fig. 4 (*right*). Studio B control equipment in foreground; Studio C, in background, under construction.

tion to the present 5,000 square feet, including two additional studios approximately 1,600 square feet each, allowing for three sides of the studios to serve as "sets."

2. A total of five live video studios equipped with dual vidicon camera chains including viewfinders, multiple lens mounts, waveform monitors and switchers operated from standard RETMA sync.

3. Six operating channels, five to be utilized by live studio equipment, the remaining for film use.

4. Twenty-one elementary schools and two high schools receiving an aggregate of 27 lessons daily on approximately 510 television sets.

5. Approximately 12,000 students participating in the direct and supplemented instruction program.

Other areas under consideration for the 1957 school term involve these possibilities:

1. Erection of a low-power ultrahigh-frequency (uhf) transmitter for telecasting instructional programs to community at high school and junior college level.

2. Installation of microwave equipment for two-way telecasting to the teachers college in a nearby community.

3. Equipping mobile unit for local temporary special event coverage.

The opening of the September 1958 school term will conclude the technical expansion of the five-year project. The anticipated additional equipment requirements include the following:

1. One live color studio equipped with dual camera chains.

2. Approximately 60 color receivers.

3. Twenty-five additional school distribution systems for the balance of the schools in Washington County; approximately 8,000 additional students will be involved.

4. Approximately 400 additional televisions sets to be added to complete the service.

CONCLUSIONS

1. Through the use of multiple transmitters, each operating on a different frequency, it is practical to transmit several lessons simultaneously.

2. It seems more practical when several studios are used to group originating equipment at one location which may be referred to as a television center. It also seems desirable to select such a location away from the regular school area.

3. Standard television receivers serve such an application quite well. For economical reasons it would seem practical to use regular line models. It is desirable to use models with front-mounted speakers with relatively high-level output capacity. Tuning controls should be conveniently located.

4. Professional type vidicon equipment is most flexible in mass-media applications. Demonstration amplifier vidicon techniques are quite adequate for certain large-group viewing, such as in auditoriums.

5. Broadcast television studio techniques are desirable for production effectiveness in this type of service.

6. In new building construction, consideration should be given to the following:

   a. Control of inside lighting in order to utilize essentially indirect lighting during the viewing periods.
   b. Control of outside light to remove reflections and glare from television screen.
   c. Adequate conduit to classroom areas to provide multiple cable installations; such as 4- by 4-inch side drop.
   d. Furniture or room design to provide mounting space for television receivers along the line of custom installation practices, including conduits for signal cable and standard 110-volt a-c outlets.
   e. Room configuration to permit normal set arrangements when viewing television with consideration of the distance from the television set to any student.
   f. Forced ventilation in classroom areas to minimize or eliminate need for open windows which may present outside light control problems.
   g. Consideration for large screen projection rather than television set presentations.

7. Television offers tremendous potentialities in televised education in the following ways:

   a. Ease and expediency in presentation of instructional information.
   b. Facility of magnification of picture information by choice of lens.
   c. Ability of the teacher to concentrate the students' attention on a fixed area.
   d. Uniformity in instruction.

Finally, to say that, had he lived longer, Einstein may have been a direct classroom instructor for every science student in the country through the medium of television, may be the understatement of the century.

Colombia Electric Project

Colombia's Laguneta hydroelectric project, among the largest and most spectacular of its kind in South America, is scheduled for completion some time this summer. The $13.5 million project, capable of producing 60,000 kw of power, is one of a series of power projects which are being undertaken by Colombia's National Public Service Corporation.

Expansion of industrial and commercial facilities and the increase in residential needs for electric power will make necessary the addition of other power stations. By 1965, Colombia expects to be producing 3 million kw for all its needs.

The Laguneta plant draws on the Bogota River for water power, with a reserve supply in nearby Lake Muna. It will be equipped with three generating units capable of producing 20,000 kw each, with room provided for two additional units when needed.

The Human Side of Automation

G. R. COWAN

To assure the success of a changeover to automation, the individual should be carefully educated, in order to overcome the human characteristic of resistance to change. In this way, the problem of adverse reactions may be greatly reduced.

AUTOMATION is a new word in the 20th Century. It has been accredited to the Ford Motor Co. for its coinage. Its meaning is not always uniform in the minds of business management. To some, it means a high degree of mechanization of the movement of materials in the production process from work place to work place, coupled with electronic control devices for selection or rejection of materials, tools, or parts. To others, it is merely the installation of a new machine in the production line, which embodies certain control features employing electronic feedback features.

MECHANIZATION

MECHANIZATION is a term understood more universally as the evolutionary process of replacing manual energy in the production process with machinery. In this context, the incorporation of electronic control features simply means a more advanced and better machine. The business manager, who is progress conscious and perhaps more, publicity conscious, may refer to his mechanization attempts as "automation." We can be assured that labor leaders will capitalize from either point of view. Walter Reuther has been quoted by James R. Bright, writing in the *Harvard Business Review*, as saying that 200,000 men have been idled "because of automation."

CONFLICT

THE PAGES OF HISTORY have recorded the saga of this conflict. The steamboat, the "horseless carriage," and the airplane are a few of the high points. In the cradle of our Western Civilization, the age of iron was born when the Hittites learned to fabricate iron tips for their spears and demonstrated their superiority by overcoming the Sumerians on the battlefields near the Tigris and Euphrates.

Over the years man has demonstrated that he is a strange creature. His mind has searched for the new, yet he clings tenaciously to the old. He buys a new car, while affectionately clutching the brim of his old battered hat!

MENTAL ATTITUDES

IT IS A WELL-KNOWN PHENOMENON to the industrial engineer that one of the barriers to progress in the production process resides in the mental attitude barriers to new ideas in the minds of production personnel. Realization of this barrier caused Allan H. Mogensen in 1936 to conceive a program, known as work simplification, to combat this barrier. Each year since that date, some 36 to 42 men from various industries spend six weeks at Lake Placid, N. Y., dealing with this problem. The impact of their philosophies and efforts have been felt in industries in the United States as well as other countries. First, the science, but more specifically the "art of improvement," is the goal of this program.

THE GUN-BARREL STRAIGHTENERS

EARLY IN HIS CAREER, Mr. Mogensen was a consulting engineer. One of his early experiences brought him face to face with the problem. The following anecdote tells the story.

Remington Arms Company had embarked upon a modernization and expansion program. The shotgun plant was to be modernized. A new building was built and the whole shotgun plant was to be moved to the new building. One of the operations to be moved was the barrel-straightening department. The workers who straighten barrels were the "prima donnas" of the shotgun plant. Their job was such that there was a special skill involved. This skill had been acquired by experience sighting through barrels and by proper interpretation of the illusion of concentric rings which appeared. By proper manipulation of a jig and anvil, barrels could be straightened to maintain the standard of quality for Remington Arms.

Needless to say, the seven men on this job enjoyed a certain high level of prestige in the social structure of the work force. They were top level in seniority and in job status level.

In setting up this department in the new location, Mogensen had gone all out. He had consulted General Electric Company engineers and had specially built seven adjustable ground-glass screens, with a constant and uniform light source behind each one. Seven new barrel-straighening devices were located in front of each screen. He had everything laid out with extreme care; he knew that these seven workers were perfectionists and supercritical, so nothing was spared in the preparation of this department in the new building.

The installation was all but completed when Mogensen (thinking that it would be a good idea to lay some groundwork with the men involved in the change) invited the senior man in the group to view the new installation. He approached Bill.

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"Bill, we have your new layout pretty well set up. I thought that perhaps you might like to come over and see it before we move you in."

"O.K.," said Bill, and followed Mogensen to the new layout.

As they walked into the new area, Mogensen was bubbling with enthusiasm for the new setup. (Mogensen's enthusiasm for change and improvement has been his trade mark over the years. He is, to the disciples of work simplification, the "human dynamo.")

Bill stopped rather abruptly just inside the door. He took a few slow steps to get a better look at the situation. He stiffened, placed his hands on his hips and his face changed to an expression of bitter criticism. "Young fellow," he said, "you may be an engineer; you may have a college degree; but it's plain to see that you don't know anything about straightening shotgun barrels."

"What's wrong?" asked Mogensen, thinking to humor the old fellow.

"Well," said Bill, "Anyone who knows anything at all about straightening gun barrels knows that you can't straighten a gun barrel unless you have north light! And, if you think any of us are going to work with the contraptions you have set up, you've got another think coming." Bill turned on his heel and stalked back to his work area.

Mogensen was somewhat shaken, but he took the following steps. He double-checked the boys at General Electric. They, in turn, set up an investigation to answer the following questions: Could there be quality present in "north light," i.e., the light from windows facing the north, that was not present in the light source that had been provided, which could possibly affect the barrel-straightening operation? None could be found. In fact, all evidence pointed to the superiority of the ground-glass screens. Uniformity was better; they were not affected by variations in the weather; diffusion was better; further, the screens could be adjusted to the straightening equipment.

After this was assured, the following course of action was taken, which got results. However, Mogensen is the first to admit that it was not the way the whole program should have been handled.

Starting with the first floor, department after department was moved to the new building. It was getting along toward early winter. As each floor in the old building was cleared, the heat in the old building was shut off. By the time all floors were vacant below the straightening department, the heat on the top floor was not always what it should have been. The gun barrels were all trucked from the new building over to the top floor of the old, straightened, and then trucked back to the new building for assembly and shipment. The straighteners, by now, were sometimes cold, but most of all they were getting lonesome. They were no longer in the center of things; their old status and prestige levels were being destroyed. Bill took action.

One day he asked if he might try the new equipment, which was gathering dust in the new building. Of course, he knew you couldn't straighten a gun barrel on it, but he wanted to try it anyway. One by one, the seven men moved over, and the old building was then torn down. The incident still lives. Mogensen's concept of "resistance to change" has become a large heading in the master notes of the work simplification program.

PERSONAL INVOLVEMENT

THE EXPERIENCE of more than 20 years by those who have been co-ordinating work simplification plans in industrial, commercial, and civic organizations throughout the country has gradually changed our approach to the problem of resistance to change.

People resist change because of habit. They resist change because of the comfortable feeling ("complacency," we called it) of performing in a known behavior pattern. We resist when something new threatens that comfortable feeling. To combat resistance, we employed facts and logic that tend to show that there can be no progress without change. We poked fun at the typical executive who had built an organization only to vow vehemently that he is in favor of progress. However, he would "be d—— if there were going to be any changes" in his department. We developed material showing the facts of change and its effect on our economy, our standard of living, our leisure time, etc. We use films from authoritative sources. "Machinery Creates Employment," produced by the Ford Motor Co., is one such film. "Productivity—Key to Plenty," produced by the Twentieth Century Fund, is another. Excellent as they are, these films seem to fall short of their goal. If we are to combat resistance to change, it becomes obvious that we would need to use some additional approaches, if we hope to change attitudes and affect habit patterns. Something was lacking in this approach.

Another approach, used concurrently with the one just discussed, is the analytical approach. The work simplification philosophy, coupled with the analytical approach to improvement, has this distinctive feature. Since human beings are known to resist when changes are foisted upon them, this difficulty may be circumvented by having those affected initiate and help institute the change. To put this philosophy into a program of action, it follows that instruction and training in the use of the tools of methods analysis need be given to all individuals who become involved in change and improvement.

From work simplification experience of many using it, it has been learned that "The person closest to an operation or function is in the best position to improve it." This is not to say that such an individual is most qualified by training or experience, it simply means that proximity to the operation gives him an advantage in that one respect. Our goal is to take individuals in this position and train them in the basic tools and techniques of analysis, so that they can better take advantage of their favored position with respect to the operation or function.

This approach has proved to be effective over the years; however, it has fallen far short of the potential that is basic to the process. In other words, we did not have the complete answer. However, past experience with this

technique has demonstrated the following principle of human behavior related especially to our industrial life: People tend to lose their resistance to change in an inverse relation to the extent of their personal involvement in making the change.

In consideration of human factors related to automation, it is my belief that the aforementioned principle must be considered as a human element which applies during the transition period of each step of the way toward the fully automatized production line or office system. The acceptance of this principle will be difficult. Management personnel will encounter some human factors which will promote personal involvement of those affected. Of course, we will not recognize it as fear, we will simply rationalize it thus: "No use getting everyone all stirred up in advance, let's get the thing all worked out, and when everything is all set, put it in!" My some 12 years' experience in industrial engineering gave me more examples of what happens in instances like that than I'd like to admit. It rarely is anything short of a trying experience. Why we haven't learned to use the simple methods improvement principle of combining operations, i.e., work out the human side concurrently with developing the mechanical side, I will never know. I have had enough work simplification experience using the "personal involvement" principle to know, however, that it can and does work!

Although I am enthusiastic about the use of the principle of involvement, let me inject in the discussion here a word of caution. The single individual in a large organization who makes an attempt to use this principle, without it being an accepted principle of the entire management team, may find himself branded as a troublemaker and an irresponsible maverick, particularly so unless he confines such tactics to his own bailiwick.

CONSULTATIVE MANAGEMENT

THIS BRINGS US to a second consideration which will have a bearing upon the human factors in automation. The automated line will mean a gradual breakdown of the individual empires in an industrial organization. Automation will tie together mechanically both basic operations and suboperations. It will necessitate a more integrated functioning of various departments. For example, the self-sufficient and independent department manager can no longer exist as almost a separate entity from the remaining departments. He will have to learn the arts of teamwork as opposed to self-sufficiency; he will have to learn the arts of consultation and group concurrence rather than the exercise of independent judgment. He will find, I believe, that of the three ways of getting results through people, he will seldom "tell"; he will find reduced occasions to "sell"; but will find more and more occasions to "consult." "Consultative management" will be the order of the day.

The rather clear-cut separation of function and responsibilities of line, staff, and technical departments will gradually disappear. Production decisions will be made less and less by production department heads, (thence passed down the line chain of command), but more and more by groups composed of electrical, electronic, hydraulic, and mechanical engineers and technicians. The successful managements may find that they have learned to deal with the human factors rather than material, technical, and mechanical aspects of production. The arts of both conference leadership and conference participation follow workable rules and procedures consistent with the consultative management concept.

FEAR

THE HUMAN SIDE of automation will be attended by some reactions of fear. The statements by Walter Reuther, previously quoted, make us aware of this aspect. However, I think we need to look a little more closely at some more intimate reactions. If we look again at Bill, the gun-barrel straightener, we may see that his real reaction was triggered by fear. Fear of losing opportunity to express himself through his special skill on his day-to-day job of straightening gun barrels. He was afraid of his job being "de-skilled." In my 12 years' experience in working with methods and methods changes from an industrial engineering standpoint, I have seen this incident repeated many, many times. Of course, the individuals' expressions do not appear as fear, they appear as anger.

Whiting Williams, management consultant, who made almost a lifetime study of how workers really feel, by actual living and working with coal miners, railroad workers, steel mill workers in many countries of the world, classified workers' reactions in terms of three human feelings—fear, hope, and pride.

As important as it is to recognize the human reaction of fear, it is perhaps even more important to recognize the relative importance of the three universal human reactions as defined by Williams. While working in the coal mines in Wales, he lived and worked with an "old-timer," Evan. Evan's job was to make the round of the mine shafts, inspecting the air circulation system. Evan's job was rather a thankless one. In fact, if all was going well, no one paid very much attention to Evan. In the evenings after work, Evan consumed considerably more than his share of certain beverages. It seemed to bolster his feeling of importance. Williams was with Evan one day when all the sirens at the mine began to blow. The circulating system had stopped; the mine had to be evacuated. When the last man was above ground, Evan was called to discover the trouble. Williams accompanied him to the mine shaft. Evan appeared as a man transformed. Dangerous as it was, Williams followed him. He wanted to find out more about this man who had suddenly come to life. He soon found out. As old Evan swung along the lower mine shaft in search of the trouble, he turned and said, "You see, they need old Evan now. The whole mine will be shut down until I find the trouble."

I retell this incident of Mr. Williams to illustrate some principles which he has concluded from his experiences:

1. "Saving his skin is of less importance to a man than saving his face."

2. "The hunger for food is less important to a man than the hunger for attention and recognition."

We must remember that, at least in American industry, a man gets his feeling of being a man from his job. He gets his feeling of recognition from his superiors. It seems to me that in planning for automation we should allay fears by providing hope in the future, and arrange for feelings of pride of accomplishment for workers in the automated plant.

NEW GOALS

NEW GOALS, new criteria for measurement of personal worth, will have to be established for each man. In the automated plant, to replace the feeling of accomplishment of the workers who had an active part in the fashioning of products by individual effort, we will have to provide for a feeling of having a hand in managing the machine, effecting improvements in the process, and assisting in the more complex man-to-man relationship to keep the machine functioning.

In order to place these goals within each employee's hope of realization, a training program will be needed. Personnel will have to depend upon the company to provide educational opportunities in the adult education field, or else they will feel trapped in a situation of the automation age. It is impossible for them to go back to their school days and recap a training program. Their formal school days are over. Public adult education has small chance of filling this need. Our overburdened present school structure will not permit it. Training offered by their companies can give them a feeling of hope, to supplant fear. It can transform the whole spirit of the work group from frustration to anticipation. The age of automation will then be entered into with enthusiasm and vigor.

CREATIVE MAN

THE AGE OF AUTOMATION will be the development engineer's dream. He will come into his own. However, much of this can be lost unless we make ample provision for some creative expressions by others in the organizational family. Man was created in the image of his Maker and he was given creative ability. He slowly dies if he has no chance to express it in some measure. Industry dare not focus so much attention upon the work of the development engineer that expression is stifled elsewhere. For example, the American Machine and Foundry Company has become aware of this situation and has taken steps to take advantage of the creative talents down the line.

I have seen power released in men down the line, have seen them express themselves creatively about their jobs, and then have seen their ideas put into use. I have seen men who have changed their personalities. Their attitudes become positive and dynamic. Their actions follow suit. Our work simplification program not only benefits us in terms of changes in morale, but it has been attended by real monetary values.

At the Massachusetts Institute of Technology (MIT) School of Industrial Management, an exciting new concept of industrial management functions is being explored. A now-recognized function of management is being defined. It is the function of "improving." This unique program is experiencing, experimenting, and developing the art of improvement from the human side, and the interaction and feedback of the human components as related to the mechanical components of industrial enterprise.

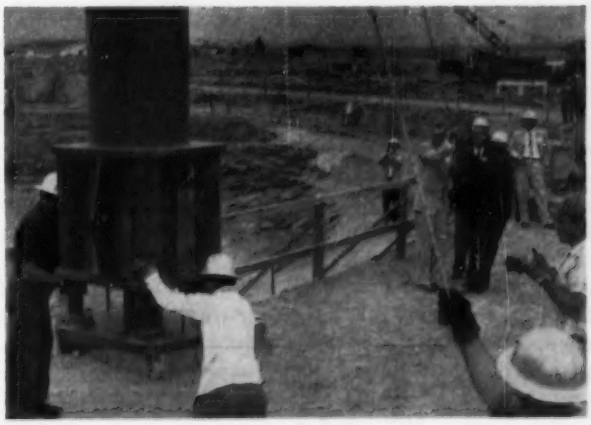
THE MIND OF THE AUTOMATED LINE

FINALLY, perhaps we should consider some of the human-like factors that automation will bring us in the machines themselves. Electrical engineers will build into our machines electronic feedback features. Our machines will have some human-like qualities in terms of control, rejection, and acceptance. I strongly suspect it will also be true that the complexity of the machine will give us a new type "resistance to change." One day automated factories may resist new products, product changes, and the like, perhaps in greater proportions than human habits do now.

It is my hope that provision can be made to use the creative abilities of every man and woman in plants of the future so that this "new resistance" can be speedily overcome.

When each of us can pride ourselves at least as much on ideas and action we generate in others as we do in generating ideas of our own, then we can all anxiously await the fulfillment of automation.

Dresden Nuclear Reactor



The first of 20 steel columns for the 190-foot steel sphere was set in place at Commonwealth Edison Company's 180,000-kw Dresden Nuclear Power Station, 50 miles southwest of Chicago, Ill., on June 12, 1957. Assisting workmen guide column are (left) Francis K. McCune (Fellow AIEE), vice-president, General Electric Company, and Willis Gale, chairman, Commonwealth Edison Company. The country's largest nuclear power reactor, being built by General Electric and to be owned and operated by Edison, is scheduled for completion in 1960.

Principles and Practices for Standardizing Laboratories

F. B. SILSBEE
MEMBER AIEE

In the past few years, there has been a large expansion in the number and size of electrical standardizing laboratories. The National Bureau of Standards has prepared a short guide designed to assist in the solution of many of the management problems common to these organizations.

UNTIL THE LAST DECADE or two the great majority of electrical standardizing laboratories were those maintained in the meter departments of electric power companies. Their duties are primarily to provide the basic measurements needed to maintain the accuracy of the thousands of watt-hour meters used on the circuits of the company, although in many cases other important functions, such as insulation checking on cables and bushings and trouble shooting, are included.

During and since World War II, there have come into existence a very large number of electrical standardizing laboratories which are charged with duties that differ considerably from those mentioned above. These new laboratories form organic parts of a great variety of industrial corporations, universities, research institutions, and Government agencies, particularly numerous branches of the Department of Defense. These newer laboratories are concerned not only with the measurement of power and energy at 60 cycles per second, but also with measurements relating to communications, navigation, automatic controls, telemetering, and many other fields, and are concerned with frequencies ranging from zero to thousands of megacycles per second.

The reasons for the establishment of these newer laboratories include not only the normal growth of our population and the increased per capita use of electric power, but also a greater realization of the necessity for making accurate measurements in all industrial activities. This necessity becomes especially important under modern conditions, wherein a wide variety of component apparatus may be manufactured by separate subcontracting units, yet must function effectively when combined in a unified system. Still another important reason for the increased interest in electrical measurements is the ever-increasing use of electrical methods for measuring nonelectrical quantities such as temperature, acceleration, chemical concentration, etc.

Revised text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., Jan. 21-25, 1957. Recommended for publication by the AIEE Committee on Indicating and Integrating Instruments.
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The National Bureau of Standards (NBS) is, of course, the fountainhead from which the flow of measurements radiates into all fields of science and engineering. Consequently, the engineers of the new laboratories have looked to that Bureau for advice and assistance in the planning and equipment of their organizations. Although the various laboratories apply their efforts to very diverse operations, it appears that a large majority of them have a considerable number of management problems in common. To assist in the solution of these problems, the National Bureau of Standards issued, in August 1956, a brief publication* entitled "Suggested Practices for Electrical Standardizing Laboratories." This circular lists some general principles usually applicable to such a standardizing laboratory. These relate to the position of the laboratory in its parent organization, the scope and accuracy of its work, and the training of its personnel. For the range from d-c to 30 kc, the circular suggests types of standard apparatus, the care of such equipment, and makes recommendations concerning the desirable intervals between successive checks on the calibration of the various kinds of standard.

TERMINOLOGY

A COMMON SOURCE of confusion and misunderstanding in laboratory parlance arises from the present lack of uniformity in the designation of standard measuring apparatus. In this publication, the term "reference standards" is used to designate pieces of apparatus, each of which embodies a fixed electrical quantity and serves to maintain some unit of measurement in the laboratory during the intervals between checks with some laboratory at a higher level. The term "working standards" designates the apparatus calibrated in terms of the reference standards and used in the standardizing laboratory for the calibration checking of other equipment. The term "shop instruments" is used to designate the instruments and apparatus used in the daily work in the rest of the plant and calibrated as required by the standardizing laboratory. A new term "interlaboratory standards" is introduced to designate the pieces of apparatus which are shipped back and forth between the laboratory to which they belong and some other laboratory, such as the National Bureau of Standards, from which the units of measurement are derived. Still another classification is "comparison equipment," which includes bridges, potentiometers, etc., and consoles used in the laboratory in

* Circular 578, available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., at 15¢ a copy.

the process by which the shop instruments under test are compared with the working standards of the laboratory, or by which the working standards are compared with the reference standards.

The circular closes with the conclusion that the most important considerations in such an enterprise are: (1) The leader must have a high degree of technical knowledge and competence in the specialized field of electrical measurement; (2) The measuring apparatus must be adequate and chosen specifically to fit the kinds of measurement and levels of accuracy demanded; (3) The checking procedures must be definite and followed carefully, but should be flexible enough to meet emergencies; and (4) The laboratory must accept responsibility for the internal consistency of its measurements, and should look to a higher echelon (such as NBS) only for its initial calibration and for periodic checks to detect drifts in the values of its reference standards.

Information Theory Impact on Modern Communications

PIERRE MERTZ

This is the second and concluding article on the impact of information theory on the development of communications systems. Topics discussed include carrier transmission, the "homodyne" detector, and the applications of information theory to pictorial transmission, facsimile, television, and telephony.

IN THE DISCUSSIONS in the first article, baseband transmission of the signals has been assumed. That is, it has been assumed that the amplitude of a direct current or voltage has been modulated or adjusted according to a given or input wave shape to denote an instantaneous proportional value at each moment.

In fact, carrier transmission is more likely to be used in practice. It was noted by Carson[32-34] that amplitude modulation of the carrier leads to symmetrical sidebands about the carrier, each of which is a replica of the baseband spectrum. The signal information is duplicated in the sideband so that a loss in efficiency results unless other steps are taken.

Such a step can consist of filtering out one sideband, leading to a single sideband transmission. Or, alternatively, it can take the form of a separate and independent modulation of the sine and of the cosine components of the carrier wave respectively. This gives two individual channels in the double sideband, which recovers the information efficiency.

These steps, incidentally, are not available (at least in this clean-cut form) to frequency modulation. Thus, the various advantages of such modulation are purchased at the price of a reduced information carrying efficiency.

Transmission by amplitude modulated carrier suggests an examination of detectors used to recover the signal. The simplest of such detectors is the envelope rectifier. This cannot recover negative excursions of the envelope as distinguished from positive excursions. When a carrier signal contains such negative envelope excursions, it is said to be "overmodulated."

The "homodyne" detector (see Hartley)[32-34] is a product demodulator which multiplies the incoming signal with the carefully phased output of a local oscillator of the exact carrier frequency and integrates the result in a low pass filter. It can distinguish between aiding and opposing phase in the incoming carrier as compared with the local carrier and, therefore, can recover distinguishable positive and negative envelope excursions. The homodyne detector has the possibilities ascribed to an "ideal" detector as developed in some viewpoints of information theory,[35] when used with an optimum noise filter. It is the detector which has been assumed earlier as available to permit the use of a "polar" carrier signal, as distinguished from a mere "on-off" signal.

The price of the homodyne detector operation is, of course, the necessity for the local carrier supply of exact frequency and phase. This can be supplied by some extra channel in the transmission, or by a periodic reference condition in the signal, during which the phase of a local oscillator can be adjusted. Because of this generally high price, some modifications have occasionally been proposed to the conventional homodyne detector for special signals.[36,37]

Also because of this generally high price, it is frequently found that economic equilibrium in the design

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of practical communications systems leads to the use of a simple envelope rectifier, in spite of its poorer signal-to-noise performance.

TIMING INDICATIONS AS INFORMATION

A POINT which is not always noted in the study of communications systems by information theory techniques is that timing indications are a form of information. This has been revealed in "Note on Theoretical Efficiency of Information Reception with PPM," by M. J. E. Golay, IRE *Proceedings*, September 1949 and in information theory study of radar return signals.[38] In these, of course, the timing indication is vital. It measures the range of the object revealed, and the ability to do this accurately is one of the major characteristics of radar.

In actual point-to-point and network communications systems, the timing may also be of importance. Some facilities are used for timing indications alone, as for example in the radio transmission of time signals, or in the synchronization of astronomical or similar observations.

In telegraph or data transmission, however, timing is also of importance (see "Transmission Line Characteristics and Effects on Pulse Transmission," by P. Mertz, Brooklyn Polytechnic Institute, vol. 3, April 1954). It is of sufficient importance in many cases, for a special portion of the information capacity to be assigned to it. The timing is important because, as was indicated by Nyquist, there is an optimum time for sampling a received signal impulse to determine its amplitude (or when in a binary code, whether it is marking or spacing).

This timing information, on a hypothetical basis, can be set during a lining-up period and need not be repeated. Or, it may be derived from signal transition times, as in the Baudot quadruplex.[39] But, for practical purposes, it is found desirable to repeat this fairly frequently, as there may be short occasional circuit interruptions or bursts of noise that lead the receiver to lose count. This repetition permits the receiver to start afresh with a minimum of lost time.

The timing information is assuming particular importance in pulse code modulation (PCM) systems (discussed later in this article) where regenerative repeating is used.[40,41] In such cases, it is essential that the regeneration cover exactness in the timing of the regenerated pulses, as well as in their wave shape. It is also essential that whatever is used as timing channel also be regenertated in such a way that the timing accuracy is not too much impaired.

APPLICATIONS TO PICTORIAL TRANSMISSION

THE OBJECTIVE of a fairly large group of communications systems is the transmission of two-dimensional pictures. These include facsimile (both photographic and the cruder direct recording) and television systems.

In these systems, the end result is a picture seen by the ultimate viewer. The principal requirement really is that his subjective needs be satisfied. These needs cover such things as perceptions of sharpness, tone rendering, contrast, freedom from extraneous patterns and fringes in space or in time (the latter including flicker and stroboscopic and after-image effects), and color rendering (in color systems).

Such subjective perceptions would not immediately be expected to be measurable in terms of information content. This is, of course, quite so and, in some instances, the fact has been corroborated. Nevertheless, it has been found that the techniques of information theory have been quite powerful in the engineering of transmission systems for pictorial communications.

In particular, it has been found that the logon carrying capacity of the system (i.e., the number of independent picture luminance values per second that can be transmitted) as measured by the frequency bandwidth available, correlates reasonably well with the resolving power and sharpness of the received image. It is clear that inasmuch as the optical profession has been searching for many years for an objective measure of sharpness, and have succeeded in getting only a rather loose correlation,[42-44] that the correlation for facsimile and television cannot be expected to be any more precise. However, at least a reasonably workable measure of this aspect of picture quality has been obtainable from the information theory approach.[45-53]

This has been so successful, indeed, that the optical profession has itself begun to try the approach in some of their problems of optical degradation.[54-56] In this technique, the subjective degradation is identified with the drop in reproduced information caused by the impairment.

The National Television System Committee (NTSC) standards on a color television broadcast signal, adopted by the Federal Communications Commission (FCC), have also made use of conclusions from information theory.[57] It was long known that the composition of a conventional television signal is such as to make rather inefficient use of the frequency space used for the information transmitted.[58] Even earlier, Gray suggested the interleaving of three channels for color transmission.[59]

Later, it was further discovered that the eye appreciates chromatic information less, in the resolving of image detail, than it does luminance information. It even needs less chromatic information for certain color groupings than for others. Thus, it needs less logon content in the signal or a lower frequency band for a purely chromatic than for a luminance signal, and less for one of the chromatic signals than for the other (if the two are suitably chosen).

In the NTSC signal, the two chromatic channels are much narrower than the luminance channel, and one chromatic channel is narrower than the other. The two chromatic channels are then multiplexed on the luminance channel by interleaving in the same frequency space.

In this manner, the same frequency space as used for a monochrome television signal is made to carry more information for the color television signal. The extra information has been tailored as far as possible to the subjective needs of the ultimate viewer, and inserted in inefficiently used portions of the original signal.

In recent times, serious proposals have been made for

reducing the inefficiency of transmission of monochrome television.[60] This, of course, has been an objective for many years, but the results have been disappointing until very lately. Even this proposed system is usable only where the signal has been translated from its normal or analog form into a digital form. The proposal consists in separating the high-frequency components from the low-frequency components of the signal and separately translating them into digits. The low-frequency digits, which come relatively seldom, are translated with customary accuracy. The high-frequency digits, which come at a high rate, are translated on a very coarse scale of gradations. In an experimental system, this reduced the frequency band required for the digital transmission to about half.

INFORMATION THEORY APPLICATIONS TO TELEPHONY

THE APPLICATION of information theory to telephony again brings in the subjective factors that have been noted with regard to pictorial transmission.

This matter gets into the problems of the intelligibility and entropy in linguistic processes. Studies have been made of the point both for written and auditory languages. There are of course two basic steps in coding an idea into a telephone line signal. The first is to express the idea in terms of a language. The second is to translate the language into line signals. In the speech form, the language consists of a succession of elementary sounds which are called "phonemes."

It is not expected that in telephony the speaker will modify his speech to increase his efficiency or reduce redundance in the first step. It is, however, of interest to know the amount of redundance in that it gives an idea as to how much the signal may be distorted in transmission without destroying the sense conveyed by the speech.

Shannon[61] has made some estimates of this for a printed English text of 100 characters, on the basis of asking a subject to guess the successive letters, and noting the statistics of correct answers. This redundancy comes out, in his terms, of the order of 75%. Fry[62] has carried out this test with spoken English counting phonemes instead of letters. He comes out with a redundancy of the order of 55%.

As regards the second step, one may note that according to the speed of speech, one may utter from 2 to 20 phonemes per second, with a possible "typical" value of 8. The number of phonemes, say in English, varies according to point of view. If one aims primarily at intelligibility and considers closely similar sounds as one phoneme, the number perhaps is in the 50's and each can be identified by a 6-bit signal. If one aims at fine distinctions, this number exceeds 100, and about 7 bits are necessary. This means merely that intelligible speech requires some 12 to 120 bits per second of basic information. A typical value might be 50. If finer distinctions of speech are considered, the numbers run only from 14 to 140. A little more should also be added for average pitch indication, and possibly for other indications characterizing expression.

Experiments have been carried out to determine the various fundamental transmission requirements for a telephone circuit to transmit speech in the conventional manner, and with a degree of ease deemed suitable for message communication.[63,64] These lead specifically to frequency band needs of the order of 3,000 cycles.

A 3,000 cycle band is very inefficiently used by a process which conveys only some 15 to 150 bits per second of information, especially when more than half of that is redundant to the ideas expressed. The fact illustrates, however, why it is possible to carry out the speech transmission under very unfavorable conditions and still retain a useful degree of intelligibility. It also illustrates why it is more difficult to use a telephone facility for data transmission than for speech transmission (in addition to the fact that it was designed for speech in the first place).

Because of these considerations, there has been effort in a number of directions to transmit speech in a narrower frequency band than used by a conventional telephone circuit. Essentially, the problem arises from the fact that the "code" which is used to represent the voice, namely, the analog connection between the signal voltage and the instantaneous air pressure (or velocity) in the region between the speaker's mouth and the microphone, is not an "efficient" code. It is necessary to beware of any "efficient" code development that depends upon a long code group for its efficacy. Because if too much encoding and decoding time is required, this can quickly impede the flow of conversation. Such a flow is one of the outstanding advantages of telephony over other media of long distance communication, and its possibility is of great importance to the art.

Of the various efforts to improve the coding efficiency of speech, the one that probably has been pushed the furthest toward a practical realization is the "Vocoder."[65]

The objective of the Vocoder is to correlate the speech to some degree with the mechanism of the voice. In one form of the scheme, the 3,000 cycle speech spectrum is divided into 10 bands, and the energy in each noted. This is communicated to the far end in channels that have a 25 cycle baseband (or 50 cycle double sideband width). An eleventh channel, of the same width, indicates the fundamental pitch. At the receiver, these signals control the intensities (in the original bands) of a sound stream consisting of a hiss or a buzz (the choice of these two being under control of the pitch channel). The entire speech channel is, therefore, reduced to some $11 \times 50 = 550$ cycles, and could be reduced further by vestigial sideband transmission through the individual channels, if necessary.

Thus, the net contributions which information theory has made to conventional telephony are an awareness of the price paid in information efficiency for the simplicity that characterizes the ordinary message telephone system, and the means that can be used to increase this efficiency in cases where the economic equilibrium warrants it.

Telephony, in addition to this, also comprises switching and signaling circuits that have much in common with the binary code pulses of telegraphy and data transmission. In these circuits, the contributions of informa-

tion theory run along much the same paths as for those two other arts.

In recent times, there has been much consideration of the possibilities in a conversion of the speech signal itself into a binary digital code. This is called "pulse code modulation," or PCM.[66] When the signal is in such a code form, it greatly resembles a digital data signal. The principal differences are: (1) that interruptions for synchronizing or other auxiliary signals, where necessary, be kept down to very small intervals of time in order not to interrupt the free flow of speech; and (2) that the criteria for permissible error rates be different. Aside from these differences, all of the objectives for the improvement of data transmission by the application of information theory hold. The further advantage over data transmission is that the facility obtained is not just a byproduct of a much more widely used facility, and the new plant, therefore, can be tailored specifically to the PCM transmission.

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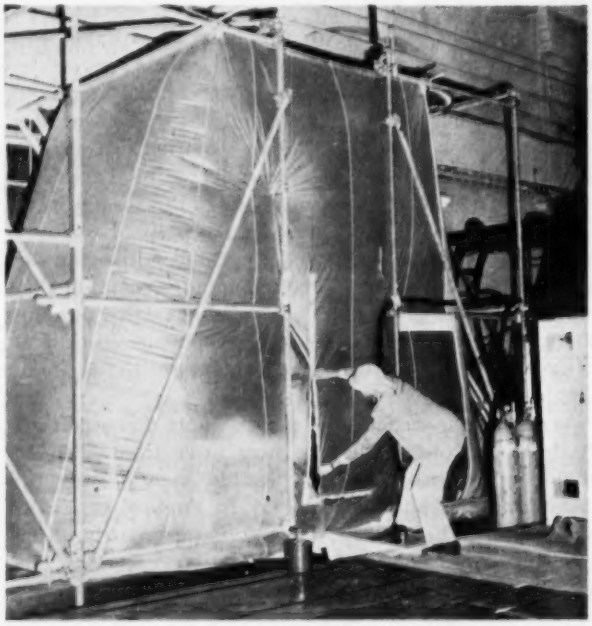
Translucent Fabric



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A High-Frequency Magnetic Servo Amplifier

W. R. SEEGMILLER
ASSOCIATE MEMBER AIEE

THE ADVANTAGES of operating magnetic amplifiers at frequencies higher than the usual 50 to 400 cps are improved transient response and reduced size and weight.

Recent developments in small high-frequency generators for aircraft and missile applications have provided a source of high-frequency power suitable for driving the output stages of magnetic amplifier control systems.

A motor–generator set was used as a high-frequency supply for this work. The set consists of a 3-phase 400-cps induction motor and high-frequency generator mounted on the same shaft.

A circuit diagram of the amplifier is shown in Fig. 1. The amplifier consists of three half-wave bridge stages in cascade designed for operation at the 4,700-cps supply frequency.

The output of the amplifier drives a 400-cps 2-phase servo motor. The motor used in this application is the U. S. Navy Bureau of Ordnance Mark 14 size, which requires 3.5 watts of control phase power for rated torque of 0.63 inch-ounces.

Fig. 2 shows the application of this amplifier in a typical position servo loop using 400-cps synchros for the position error signal and a 400-cps tachometer for rate feedback.

Operation of the amplifier at a frequency higher than the motor frequency eliminates the effect of the usual drift error present in conventional magnetic amplifier systems. However, in systems requiring high amplifier gain there is still a problem, inasmuch as the d-c drift in the first stage may become large enough to drive the output stage into saturation. One solution to this problem is to couple each stage capacitively.

In this application, each stage is coupled directly and a feedback network is used to compensate for any d-c unbalance or drift in the amplifier. The feedback network, consisting of *R4*, *R5*, and *C1*, is shown in Fig. 2. The purpose of this network is to provide a feedback proportional to any d-c unbalance or drift within the amplifier. Without this network, the unbalance or drift of the first and second stages of the amplifier may be sufficient to drive the output stage into saturation. The network keeps the amplifier in the linear region of operation by providing a feedback proportional to the d-c unbalance or drift. Capacitor *C1* presents a low impedance to 400 cps, so the feedback network does not appreciably affect the 400-cps gain. Capacitor *C2* is a blocking capacitor which keeps any d-c output off the motor winding. Capacitor *C3* is the usual tuning capacitor chosen for parallel resonance at 400 cps. Capacitor *C3* also acts as a bypass for the 4,700-cps component to keep it off the motor winding.

The error caused by drift has been a limiting factor in many magnetic amplifier applications, particularly on systems requiring high accuracy over a wide range of ambient temperature conditions. Elimination of the drift problem is another advantage to be gained from operating high-frequency magnetic amplifiers in this manner.

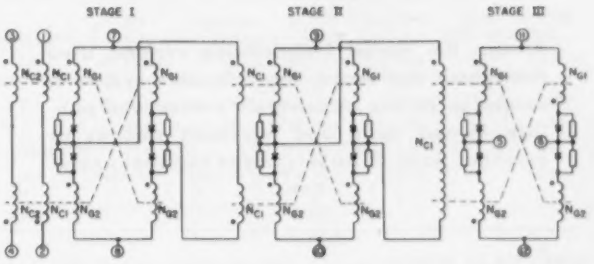

Fig. 1. Circuit diagram of 3-stage half-wave magnetic amplifier. Dotted lines indicate windings on same core.

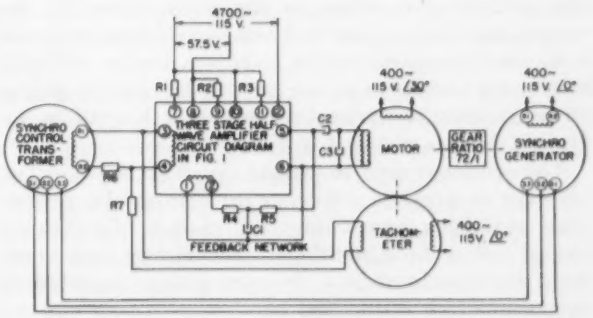

Fig. 2. Schematic diagram of position servo. (*R1*, *R2*, *R3* = 200 ohms; *R4*, *R5* = 24,000 ohms; *R6*, *R7* = 10,000 ohms; *C1* = 2.5μf; *C2* = 5μf; *C3* = 2μf.)

The amplifier has been packaged in a can 1½ by 1½ by 1¼ inches. Weight of the completed amplifier, after vacuum impregnation and potting, is only 5 ounces.

The advantages of high-frequency operation of magnetic amplifiers in size and weight reduction and in improved performance are illustrated in this application.

The usual drift error, inherent in conventional magnetic servo amplifiers, has been eliminated by operating the amplifier at a higher frequency than the motor frequency. The addition of a feedback network which responds to any d-c unbalance in the output makes it possible to cascade several stages without the danger of saturating the output stage as a result of input stage drift.

Digest of paper 57-775, "High-Frequency Magnetic Servo Amplifier for Airborne Control Systems" recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Communication and Electronics*, 1957.

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CBC Radio Service in Canada

N. R. OLDING

Among the varied broadcasting systems used throughout the world, the Canadian system is unique in its use of privately owned and publicly owned radio and television stations as essential parts of an integrated national operations.

ESTABLISHED by an act of Parliament, the Canadian Broadcasting Corporation (CBC) is a public corporation set up to carry on a national broadcasting service in Canada. Its purposes are to provide radio and television service for the entire nation; to develop Canadian programs and bring in selected programs from other countries; and to make this service available to as many Canadians as can possibly be reached, giving all as uniform a service as possible in English or in French, the two principal languages in Canada.

The continual need to expand the radio broadcasting coverage to provide service to listeners in the remote areas of Canada, to maintain and improve the existing service and to keep additional expenditures to a minimum has brought about a changing pattern of technical operation which is discussed here.

Today, Canadians accept radio as a public service which is taken for granted along with hydroelectric power and the telephone. Despite public interest in television, those engaged in both services know that more Canadians own and operate more radio receivers in 1957 than ever before. Data recently released by the Radio Electronic Television Manufacturers Association of Canada shows that Canadians purchased more than 1,300,000 radio receiving sets in the past two years.

The problems brought about by the increase in the number of potential listeners, the continuing need to expand the service to include areas not yet receiving service and the loss of audience to television during the evening hours has brought with it the need to operate the CBC's radio facilities more economically and efficiently.

The CBC programs three separate radio networks. Each of these provides service to a group of basic stations and, through network extensions, a group of supplementary stations. To provide this service the CBC rents, on a contract basis, over 14,000 and occasionally up to 26,000 miles of network facilities.

The Corporation's major network extends from St. John's, Nfld., in the East to Prince Rupert and Vancouver, B. C., in the West. For this, the Trans-Canada Network of the Corporation provides 16 hours of program service daily. This network includes 45 stations, 17 of which are CBC owned and operated. In addition to these medium- and high-powered stations, the CBC has extended its service to many remote points by the installation and connection to this network of 52 low-power relay transmitters. The remaining 28 stations which make up the Trans-Canada group are privately owned and operated.

The Dominion Network, which extends from Sydney, N. S., in the East to Victoria, B. C., in the West, is composed primarily of privately owned stations of which there are 49, and one key station located in Toronto, Ont., which is owned and operated by the CBC.

The CBC French Network, operating 16 hours daily, is composed of four major stations and two low-power relay stations owned by the CBC in addition to 20 privately owned stations. This network extends from Moncton, N. B., in the East to Edmonton, Alta., in the West.

As an additional function and acting for the Government of Canada, the CBC operates two high-power International Shortwave transmitters which are located near Sackville, N. B., and are programmed from the Corporation's studios in Montreal.

The operation of the four services represents a major engineering function on the part of the CBC and the two railway communication companies supplying the network facilities.

UNATTENDED TRANSMITTER OPERATION

IN ORDER TO PROVIDE as much service as possible with the limited funds available, each new CBC transmitter or old transmitter when replaced or brought up to date has been engineered to operate by remote control from the associated studio control point. This type of operation frees the transmitter staff so that they can perform other duties and also reduces the size of staff required to operate a given studio transmitter installation.

The new remote-controlled transmitters can be started up in stages, operated during the broadcast day, and shut down by means of push buttons or switches located in the studio plant. During the operating period, the studio or control technician can readily determine whether or not the readings of several important metered circuits are correct or, if incorrect, are too high or too

Essentially full text of paper 57-659, "The Canadian Broadcasting Corporation's Radio Service in Canada," recommended by the AIEE Committee in Television and Aural Broadcasting Systems and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Communication and Electronics*, 1957.

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NOTE: Population figures were obtained from the audience research department of the CBC and are based on the Canadian Census of June 1, 1951, projected to June 1, 1955, or census figures for 1956. In determining the urban population, the following 1951 Census definition was used: "The urban population in 1951 includes all persons residing in cities, towns and villages of 1,000 and over, whether incorporated or unincorporated, as well as the population of all parts of census metropolitan areas."

low. The frequency of the transmitted wave and the transmitted level of the program can be monitored continuously from the studio control point.

If any major unit gives trouble, a visual or audible signal warns the technician on duty at the studio that some fault has occurred. If anyone attempts to gain illegal entry, if the temperature in the building becomes unusually high, or if fire breaks out, a warning is sounded at the control point and in some cases a large gong mounted on the outside of the remote transmitter building sounds to scare off prowlers and to attract attention. In the case of fire, a heat-sensitive control element closes a circuit which operates motors closing all building air inlets and outlets. When these are closed, carbon dioxide gas (CO_2) is released within the building in sufficient quantity to smother any blaze. Other features include automatic voltage control of voltage-sensitive equipment, remote indication showing whether the transmitter tower red warning lights are on or off, and automatic recycling of the transmitter startup procedure in the event that momentary power surges or lightning discharges knock the transmitter off the air.

Manually operated disabling facilities prevent the accidental discharge of CO_2 gas, as well as the ringing of the warning gong or actuation of control point signals during periods when authorized personnel are at work in the transmitter building.

Table I. Rural vs Urban Coverage

Call	Location	Frequency, kc	Power, kw	Daytime Population TOTAL	Daytime Population Urban	Daytime Population Rural	Daytime Area square miles TOTAL	Daytime Area square miles Urban	Daytime Area square miles Rural
CBU	Vancouver, B. C.	690	10	953,200	771,000	182,200	10,100	430	9,700
CBX	Lacombe, Alta.	1010	50	858,000	511,200	346,800	60,900	295	60,600
	Coverage excludes that area which receives a stronger signal from CBK.								
CBK	Watrous, Sask.	540	50	1,122,600	381,000	741,600	256,200	420	255,800
	Coverage excludes that area which receives a stronger signal from CBW and CBX.								
CBW	Winnipeg, Man.	990	50	787,400	518,400	269,000	53,600	285	53,300
	Coverage excludes that area which receives a better signal from CBK.								
CBL	Toronto, Ont.	740	50	3,680,500	2,749,300	931,200	33,600	810	32,800
CBM	Montreal, Que.	940	50	4,418,300	3,241,900	1,176,400	52,400	895	51,500
CBF	Montreal, Que.	690	ea.						
	Coverage quoted is for CBF and is duplicated almost entirely by CBM.								
CBA	Sackville, N. B.	1070	50	1,044,600	466,000	578,600	33,600	675	32,900
Totals			310	12,864,600	8,638,800	4,225,800			

RURAL COVERAGE

On June 1, 1951, the Royal Commission on the National Development in the Arts, Letters and Sciences stated "The Canadian national broadcasting system is the result of ingenious improvision to provide speedily an extensive service in a country where adequate coverage is perhaps the most expensive and the most difficult in the world."

Canada is a country of some 16 million people, spread across six time zones. It is bilingual. Almost all of the urban population and the bulk of the rural population live in a narrow belt, about 200 miles wide but thousands of miles long, across its southern border.

As the audience becomes more scattered, the cost of providing service to each listener becomes higher because the number of listeners per square mile is reduced. A point is reached where it becomes difficult to provide service and the cost per listener becomes exorbitant.

For the most part, the privately owned and operated stations concentrated their coverage in the larger urban areas, leaving a large and frequently remote rural audience either without service or provided with an erratic and inadequate service.

The publicly owned system, on the other hand, was expected to provide service in most of these rural areas as well as in the major urban centers. Fortunately, the CBC was able to provide a large percentage of listeners with service by strategically located 10- to 50-kw transmitters. The locating of these transmitters presented many problems and the final location selected for the transmitter site was always a compromise between the best rural coverage and satisfactory urban coverage.

The rural vs urban coverage so provided can best be illustrated by some typical examples, as shown in Table I.

The list of stations in Table I does not represent all of the sound transmitters owned and operated by the CBC. Fourteen other broadcast band transmitters, located at major population centers from St. John's, Nfld., to Prince Rupert, B. C., two short-wave transmitters, 54 low-power relay transmitters and four FM transmitters serve to round out the national sound or radio service. Two 50-kw short-wave transmitters operated for the International Service by the CBC provide coverage in several foreign countries.

Although some of the 50-kw transmitters provide satisfactory service in provinces and time zones outside those in which they are located, there is a practical and economical limit to the extension of coverage by increasing the power output of transmitters.

LOW-POWER RELAY TRANSMITTER OPERATION

Field tests made with a low-power transmitter set up in a mountain valley in British Columbia in the summer of 1940 confirmed a CBC engineer's belief that a small transmitter with a power output of 20 to 25 watts could provide a reasonably satisfactory service in isolated communities where the more concentrated population did not exceed 10,000.

Although the normal range of a station of such limited power would not exceed a radius of 3 to 5 miles, it was found that a small part of the radiated power could be introduced into the local telephone, telegraph, and carrier circuits by locating the transmitting antenna within 50 feet of the overhead wires and that this could be done without creating serious interference with these services. By a further utilization of the carrying effect of the open copper-wire lines, it was possible to provide usable

Table II. Low-Power Relay Transmitters

Call	Location	Approximate Population Urban	Approximate Population Rural	Stub Line From Nearest Network Repeater Station, miles
ONTARIO				
CBLJ	Jamestown	—	3,000	65
CBLG	Geraldtown	3,600	900	46
CBLR	Red Rock	1,400	2,600	47
CBLC	Chapleau	2,700	700	—
CBLE	Beardmore	—	1,400	48
CBLN	Nakina	—	800	28
CBLS	Sioux Lookout	2,700	1,300	46
CBLH	Hornepayne	1,300	200	50
CBLL	Longlac	—	1,500	18
CBLW	White River	—	700	46
CBLB	Schreiber	2,500	1,500	41
CBLF	Foleyet	—	900	—
CBLA	Atikokan	—	3,100	111
CBLD	Dryden	2,900	1,900	90
CBLM	Marathon	1,500	2,300	51
TOTAL	15	18,600	22,800	
Total output, 300 watts. Potential audience per watt of output: urban, 62; rural, 71.				
NEW BRUNSWICK				
CBAB	Grand Falls	2,700	9,200	
CBAM	Edmunston	12,000	1,000	
TOTAL	2	14,700	10,200	
QUEBEC				
CBFG	Gaspe	1,900	13,700	
CBFB	Megantic	6,800	6,800	
TOTAL	2	8,700	20,500	
ALBERTA				
CBXB	Banff	5,100	400	
CBXL	Blairmore	5,100	3,600	
CBXJ	Jasper	2,300	100	
CBXC	Coleman	2,600	2,800	
TOTAL	4	15,100	6,900	
BRITISH COLUMBIA				
CBUG	Kaslo	—	1,200	
CBRF	Fernie	2,500	3,000	
CBRO	Greenwood	1,900	5,000	
CBXE	Golden	—	1,500	
CBXM	McBride	—	1,700	
CBUC	Salmon Arm	2,600	12,300	
CBRM	Creston	1,800	4,800	
CBUE	Hope	1,900	3,600	
CBUK	Kitimat	—	8,000	
CBRN	North Bend	—	1,300	
CBRQ	Quesnel	1,800	3,700	
CBRA	Revelstoke	3,200	800	
CBRJ	Grand Forks	1,900	4,500	
CBRL	Williams Lake	—	2,100	
CBRR	Cranbrook	4,100	2,700	
CBUF	Ocean Falls	*3,200	100	
CBRG	Prince George	**5,300	3,200	
CBRK	Kimberley	6,600	2,700	
CBUB	Osoyoos	—	2,600	
CBRE	Lytton	—	700	
CBUD	Castlegar	1,500	5,300	
CBUA	Oliver	1,100	5,800	
CBXN	Natal	—	2,600	
CBRS	Smithers	1,300	1,100	
CBRV	Vanderhoof	—	2,300	
CBRB	Burns Lake	—	2,300	
CBRC	Terrace	—	2,100	
CBRD	Field	—	700	
CBRP	Princeton	2,400	2,300	
CBRT	Ashcroft	—	1,700	
CBRH	Hazelton	—	600	
TOTAL	31	43,100	92,300	

Total output: 620 watts. Potential audience per watt of output: urban, 70; rural, 150.

* Network unavailable, served by short wave and broadcast band from Vancouver. Frequency diversity receiver.

**This town now has a small, privately owned broadcast transmitter in addition to the CBC relay unit.

service to small communities, ranchers, farmers, sawmill workers, and railroad men where the residences were located near the right of way of such lines and up to a distance of 60 miles from the low-power transmitter site.

By this means, many previously unserved areas, through which the network lines passed or which could be tied in to the network by means of a stub line, could be provided with network program service. The first station of this type to be placed in operation was installed in Revelstoke, B. C., on October 22, 1940. This initial unit had not been designed for 16-hour-a-day unattended service. In view of this and other shortcomings, a transmitter unit was designed especially for the purpose.

Some of the requirements were as follows:

1. Inasmuch as the contract for the national radio network service had been placed with the two major Canadian railway companies, the transmitter would have to feed an antenna which could be conveniently and unobtrusively erected on railway station property rather than one designed for maximum efficiency.

2. The antenna tuning and coupling unit should provide a direct copper-circuit path from antenna to ground so that static charges could not build up and break down components.

3. The power output should be between 15 and 25 watt and antenna coupling facilities should permit this output to be fed to antennas having a wide range of reactance and resistance values.

4. Some form of lightning gap and choke should form a part of the installation.

5. The tube line-up should be simple and efficient.

6. The unit should provide long and reliable service when operated on poorly regulated or fluctuating sources of power supply.

7. A minimum of meters and panel-controlled adjustments, consistent with reliable operation, should be used.

8. The power supply should be broken down into fused and sectionalized units to provide good regulation and ease of servicing.

9. The mechanical construction and wiring harness should permit sectionalized chassis units to be removed and replaced readily.

10. The audio frequency response should be equal to, or better than, that of the associated network lines, that is, $\pm$ 2 db from 100 to 5,000 cycles.

11. The audio input should be arranged to provide bridging input or direct termination across a 600-ohm line and the built-in speech input amplifier should permit operation at 90% modulation with line levels as low as −10 to −20 db.

12. All components should be operated well below rated capacity.

13. Servicing should be as simple as possible.

14. The unit should be capable of operating for periods of 4 months or longer between periodic maintenance inspection calls.

As no ready-made equipment incorporating these features was available on the market, arrangements were made to co-operate with a radio manufacturer in the design and construction of a prototype unit. When this

proved satisfactory, additional units were manufactured and a detailed maintenance manual was prepared so that technicians with little experience could locate and repair minor faults and replace defective tubes and fuses.

The first of the new units (Fig. 1) was installed in Revelstoke in July 1942, and a unit of this type has been in daily operation since that date. In this system, as shown in Table II, 54 units are now in operation, providing national network program service for 16 hours a day to some 62,500 additional radio homes and a potential audience of approximately 250,000 listeners.

Many valuable suggestions have been received from technicians and engineers in the field whose duty it is to install and maintain these units. From time to time, improvements have been made in the basic design with the result that new or converted units will normally provide uninterrupted service, other than failure of primary power service, for periods of 8 months to well over a year.

Although these miniature transmitters have been designed to operate with little or no attention, it has been CBC practice to install them in telephone, telegraph, or railway stations, and arrangements have been made with the technical or nontechnical staff at each point to provide the minimum of service required to assure satisfactory operation.

In the event of unexpected failure of tubes or other components, arrangements have been made, at most points, whereby a qualified local technician or citizen will provide emergency repair service. If the local technician cannot locate or repair the fault, a telegram is sent to the nearest CBC supervisory office and a technician is dispatched immediately to locate and repair the fault.

As a matter of interest, the high-power transmitters listed provide service to 41.5 potential urban listeners and 13.6 rural listeners per watt of output power. The annual operating and maintenance cost excluding network costs and depreciation but including salaries of staff, maintenance of buildings, grounds, tube and part replacements, power, heating, etc., averages about $7.70 a year per 100 listeners.

Operating to an audience prepared to accept a somewhat less exacting service, the low-power relay transmitters in Ontario serve an urban audience of approximately 62 and a rural audience of 71 per watt of output. The average operating and maintenance cost, excluding network and depreciation costs, is approximately $3.04 a year per 100 potential listeners.

When stub network costs from the closest contact with the Trans-Canada Network are added to the operating cost, the cost of serving each potential listener in the typical group served by the 15 relay transmitters in Ontario is approximately $1.85 per year.

The average cost of the power, space, limited service, semiannual inspections, emergency trips, tube and equipment replacements, and other costs excluding depreciation, averages, in the case of the aforementioned 15 units, $1,254.40 per unit per year, of which sum $54.40 covers the cost of all inspections, maintenance and emergency trips, tube and component replacements, and local emergency service.

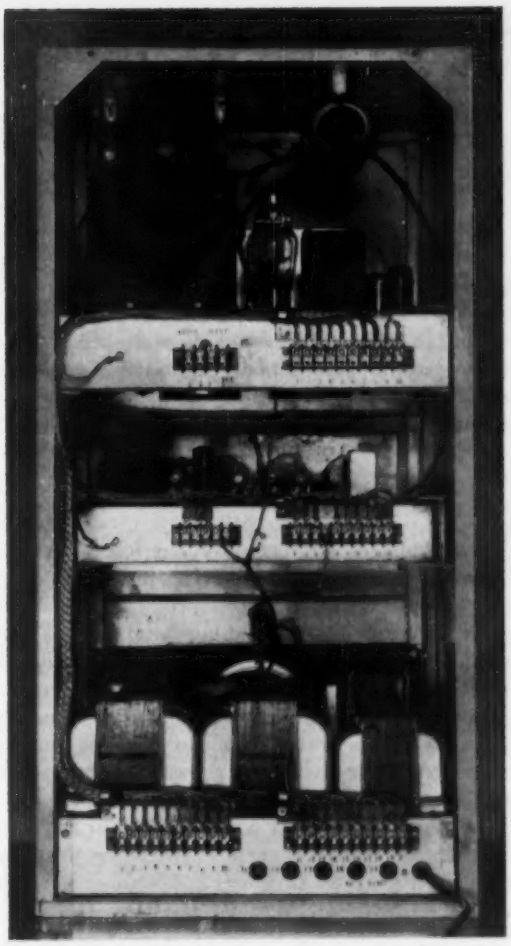

Fig. 1. Rear view of the CBC's low-power relay transmitter.

CONCLUSIONS

The data presented in this paper and the experience gained in the operation of the equipment described leads to the following conclusions:

1. Radio broadcast transmitters, when designed for operation by remote control and when housed in a building designed to permit this type of operation, can provide service equal in all essential respects to similar attended units.

2. Unattended or semi-attended 20-watt relay transmitters can provide a useful radio broadcast service in areas remote from the larger centers of population and will, with very few exceptions, provide this service for periods of four months or more between periodic maintenance inspections.

3. Either or both of these forms of operation can reduce technical manpower requirements and operating costs.

REFERENCE

1. British Columbia's Broadcast Relay System, N. R. Olding. *Electronics*, New York, N. Y., Sept. 1944, p. 92 *et seq.*

Corona Measurements on Oil-Insulated Transformers

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A description is given of a technique recently devised which permits the accurate determination of corona. With proper discrimination between external corona in air and internal corona in voids and corners under oil, quantitative measurements may be made on oil-insulated transformers.

CORONA IN OIL for both low-frequency and impulse voltages has been studied for many years. Corona on relatively large radius surfaces in oil was found to be very violent and often corona and breakdown values were the same. On the other hand, corona could be rather easily formed in combinations of insulation and oil, and it was found that vacuum filling was necessary to obtain reliable values. In this case, it was found that audible and visual indications came at the same time, and that inspection after such tests showed evidence of the presence of corona.[1,2] Data obtained in this way led to determination of the corona points of various assemblies and, in turn, to the construction of corona-free transformers. The presence of low-frequency corona can also be determined by radio interference meters and various test circuits. However, they lead to determination of the relative absence of corona, and not a measurement of its severity. The sensitivity of such circuits was often questionable. Only by inference could it be established that the apparent absence of corona showed no change even after long service. A test circuit has been devised which seems to enable quantitative measurements to be made, and which can be used to test apparatus. The results of some tests on apparatus are given.

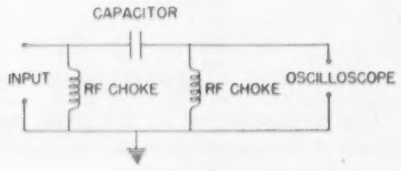

Fig. 1. Corona detection circuit suggested by G. E. Quinn.[3]

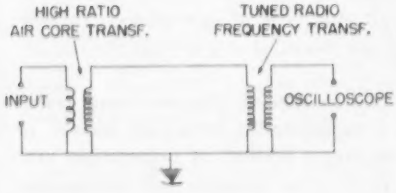

Fig. 2. Proposed corona detection circuit.

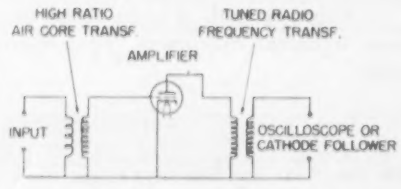

Fig. 3. Proposed corona detection circuit with amplifier.

CORONA MEASUREMENTS

ONE OF THE EARLIEST DEVICES USED was one devised by G. E. Quinn.[3] Many modifications have been used, but in essence it consists of radio-frequency chokes and a capacitor, as shown in Fig. 1. A description of several circuits used are given by R. J. Hopkins, T. R. Walters, and M. E. Scoville.[4]

These circuits are characterized by the ability to measure the charge involved in the corona pulse. It is given as $I = C\Delta E$, where I is expressed as intensity in micro-microcoulombs ($\mu\mu$coulombs). C represents the capacity of the test sample in farads. It will be seen that since ΔE is the change in voltage due to the streamer or pulse, the sensitivity is a function of the capacitance.

It is also to be noted that the chokes used were not very rugged, nor did they have any appreciable current capacity. Hence, although they might be used in testing transformers, there might be a little hesitance in grounding a transformer tank through such a device. Therefore, some study was made of alternate methods and a new circuit devised and tested.

A NEW CIRCUIT FOR CORONA DETECTION

IT WAS CONCEIVED that a circuit similar to that shown in Fig. 2 might be used. It consisted of an air-core transformer, with a heavy primary winding having considerable current-carrying ability. The secondary winding had many turns. An r-f transformer could be tuned to it, so that the 60-cycle or other low-frequency wave would be entirely obliterated. For more refinement, an amplifier and cathode follower were added later as shown by Fig. 3. It was decided to determine its calibration and general performance as described in the following paragraphs. A mathematical treatment to confirm the behavior of the device is shown in the Appendix.

Full text of paper 57-636, presented at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Recommended for publication by the AIEE Committee on Transformers. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

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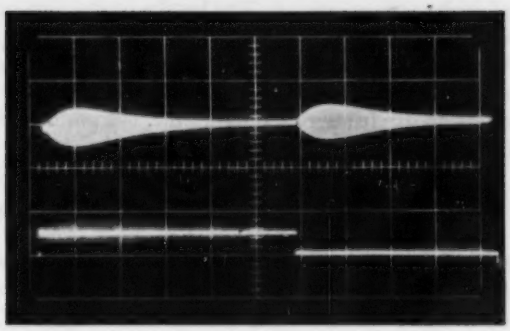

Fig. 4. Corona detection circuit calibration. Oscilloscope sensitivity: upper trace, 0.05 volts/division; lower trace, 2.0 volts/division. Charging capacitance, 18.6 μμf. Sweep, 100 μsec/division.

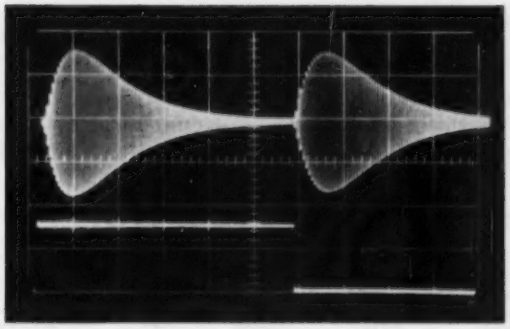

Fig. 5. Corona detection circuit calibration. Oscilloscope sensitivity: upper trace, 0.2 volts/division; lower trace, 2.0 volts/division. Charging capacitance, 96.6 μμf. Sweep, 100 μsec/division.

CIRCUIT CALIBRATION AND PERFORMANCE

Various methods for simulating corona were tried to provide a means of calibration of the corona detection equipment and to gain an insight as to the nature of corona disturbances. The most successful method was to provide a charge to the detector with a pulse generator in series with a small capacitor as suggested by another investigator. A measurable charge is then delivered to the corona detector on the front of the pulse and also at the tail of the pulse. Figs. 4 and 5 show a pulse and the resulting output of the corona detector. Fig. 4 shows the deflection caused by a charge of 18.6 μμcoulombs and Fig. 5 the deflection caused by a charge of 387 μμcoulombs. The detector sensitivity was essentially constant over this range, 1.2 millivolts per μμcoulomb for Fig. 4 and 1.1 millivolts for Fig. 5. The pulse generator used was a General Radio type-*1217A* unit pulse generator.

The effect of additional capacitance across the input of the detector was also investigated. A capacitance of 0.1 μf (microfarad) reduced the sensitivity by only 2%. A capacitance of 0.1 μf would be very large compared to that encountered in the intended application of this detector, such as the transformer tank capacitance to ground. Another effect checked was that of lead inductance in the detector ground circuit. An inductance of 50 microhenries (μh) had no effect in the circuit operation or calibration. A large inductance of 10 millihenries (mh) changed the nature of the applied pulse but did not materially change the sensitivity.

The pulse repetition rate has no influence on the circuit, provided the successive disturbances are 500 microseconds (μsec) apart. The output of the detector is a train of oscillations approximately 500 μsec in duration.

Fig. 6 is a photograph of corona from the tip of a blunt needle 6 inches away from a plane surface. The corona starting voltage was 7.5 kv. The deflection corresponded to a discharge of 113 μμcoulombs. Fig. 7 shows that a similar indication is obtained with an input consisting of a rectangular pulse generator in series with a small capacitor. The disturbance was 386 μμcoulombs. Some corona disturbances are thought to be of very short time duration, 1 μsec or less. Fig. 8 shows the response of the detector to a pulse of approximately 1 μsec in duration. The pulse generator was coupled to the detector with a 43-μμf capacitor.

The tests made show that the response of the corona detector corresponds to the change in charge of the corona input circuit. The detector has been found to be very stable in operation and will maintain its calibration. Fig. 8 also demonstrates the detector's ability to accept a signal of 1 μsec in duration and provide a usable voltage of about 500 μsec in duration.

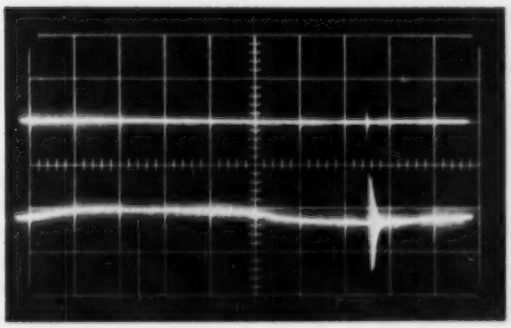

Fig. 6. Corona detection circuit response to actual corona. Voltage, 7.5 kv. Sweep, 1,700 μsec/division.

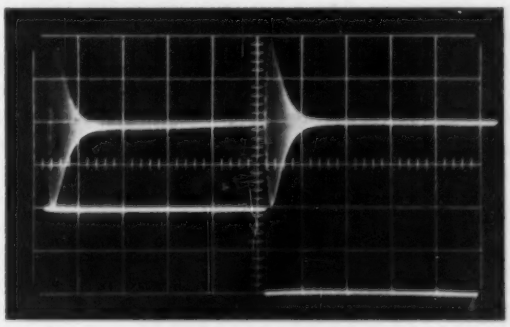

Fig. 7. Corona detection circuit response to a small charge from pulse generator. Capacitance, 96.6 μμf. Pulse voltage, 4.0 volts. Sweep, 500 μsec/division.

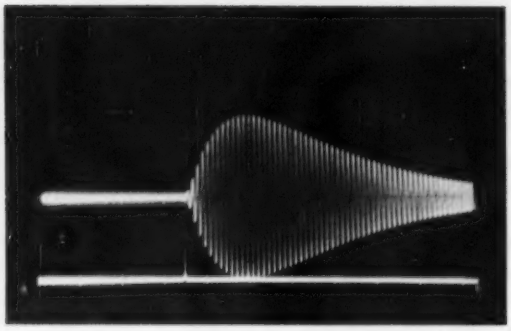

Fig. 8. Corona detection circuit response to a pulse of 1 μsec duration. Sweep, 50 μsec/division.

AMPLITUDE OF CORONA IN OIL

In order to check the amplitude of corona in oil structures, several tests have been made which show that it is ordinarily many times more severe than corona in air. Illustrative of this, the results are given of tests on a ⅛-inch thick fullerboard barrier. The electrodes were a plane and a square-edged disk. Corona, appearing abruptly, occurred at 22 kv with an intensity of 3,000 μμcoulombs. It is to be inferred that corona in oil will be at least of this order.

CORONA TESTS ON VOIDS IN INSULATION IN AIR

The test sample was an 8½-inch diameter electrode, 2 inches thick, with a 1-inch radius, as well as a ground plane and a series of 4½-inch disks of bakelite sheet. It is shown in Fig. 9.

These sheets were made as complete disks or with various size holes. The holes varied in diameter from 3 inches to ¼ inch, and one was made with a 0.040-inch diameter hole.

The method of calibration was to connect a pulser in series with a small capacitor and the detector primary. The voltage of the pulse was measured, as well as the oscillation on the secondary winding of the detector (output of detector). Both measurements were made with an oscilloscope. The product of the pulse voltage times the capacitance determines the charge in μμcoulombs. The sensitivity can be expressed in terms of millivolts secondary voltage per μμcoulomb. Typical values given by another detector, used for these tests were as follows: pulser voltage, 20 volts; capacitor, 20μμf; Q, 400μμcoulombs; oscillograph deflection, 2.8 volts; and calibration, 7 millivolts per μμcoulomb. The results of the tests on the voids are shown in Table I.

An approximate measurement of the dielectric constant of the sheet bakelite resulted in a value of about 4. On this basis, from other data, the calculated corona points are as shown in Table II.

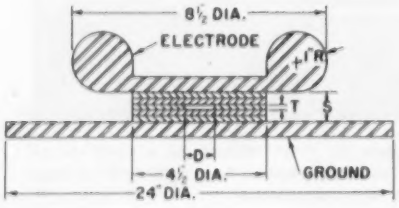

Fig. 9. Electrode arrangement for determining corona point of voids.

TESTS OF DRY-TYPE INSTRUMENT TRANSFORMERS

Five current transformers were tested, as shown in Table III. These were the first of this type of test on this type of equipment, and were taken to obtain a first "feel" as to the situation. The results show that the increase in intensity of corona obtained with voltage increase on the sample can be relatively slow. Where very definite voids can exist, as in the first unit, very high values can occur.

TEST ON DISTRIBUTION TRANSFORMERS

Corona tests were made on two distribution transformers of recent manufacture. One was a 25-kva 2,400-volt and the other a 25-kva 7,200-volt transformer. These

Table I. Results of Tests on Voids

Barrier Thickness, inches	Void Diameter, inches	Void Thickness, inches	Corona Point, kv	I (approximate), μμCoulombs
3/4	1	1/8	18	1,400
	2, 3	1/8	17	5,800
11/16	1, 2, 3	1/16	15	2,800
21/32	1	1/32	16	1,400
	2, 3	1/32	15, 14	2,900
3/8	1	1/8	12	1,400
9/32	1	1/32	8	2,150
3/4	1	1/8	20	4,300
21/32	1	1/32	16	2,600
21/32	1/2	1/32	17.5	715
21/32	1/4	1/32	17	715
11/16	1/4	1/16	17	700
3/4	0.40	1/8	21.5	715

Note: Where more than one value is given, data were taken at different times.

Table II. Comparison of Calculated and Actual Corona Points

Barrier Thickness, inches	Void Thickness, inches	Corona Voltage, kv	
		Calculated	Actual
3/4	1/8	19	18, 17, 20
11/16	1/16	16	15
21/32	1/32	15	16, 15, 14
3/8	1/8	12	12
9/32	1/32	7.5	8

Table III. Corona Tests on Dry-Type Current Transformers

Sample	Rating	Voltage	I, μμcoulombs
1	1,200/5 amperes, 15 kv	18 kv start	6,100
2	1,500/5 amperes, 15 kv	7-9 kv start	130
3	15 kv	5.5 kv start	—
		6.5 kv	143
		8.2 kv	280
4	10 kv	19.4 kv start	—
		22.5 kv	57
		25.5 kv	143
		36 kv	215
5	600/5 amperes, 5 kv	13.5 kv start	860

units were tested to demonstrate the effect of vacuum filling on the corona level. The results were obtained on the 2,400-volt transformer as shown in Table IV.

Table IV. Tests on 2,400-Volt Transformer

Condition	Voltage Applied, kv	Charge Q, $\mu\mu$coulombs
Drained for 1 hour and refilled	7	0
	9	1,000
	11	715
	15	1,430
Drained and vacuum filled	7	0
	9	143
	15	143
	19	143

Corona tests on the 7,200-volt, 34-kv test, unit gave results shown in Table V.

Table V. Tests on 7,200-Volt Transformer

Condition	Voltage Applied, kv	Charge I, $\mu\mu$coulombs
Drained for 1 hour and refilled	16	120
	20	570
	25	860
	28.5	1,430
	34	2,860
Drained and vacuum filled	20	0
	25	430
	34	430

The corona discharges with values less than 1,000 $\mu\mu$coulombs are probably from the leads in the air or adjacent ground plates.

These tests demonstrate that voids due to oil drainage can be easily detected, and that vacuum filling is very effective in eliminating such voids.

POWER TRANSFORMER CORONA TESTS

A 115-KV DELTA-CORE-TYPE 3-phase transformer was checked for corona disturbances. Before the tests were made, it was conceived that the transformer equivalent circuit could be entirely composed of capacitors, as shown in Fig. 10, where

C_{HB} = Capacitance of high-voltage bushing
C_{HG1} = Capacitance of high-voltage winding at terminal to ground
C_{HG2} = Capacitance through high-voltage winding to ground
C_{HL} = Capacitance from high- to low-voltage windings
C_{LG} = Capacitance of low-voltage windings to ground
C_{LB} = Capacitance of low-voltage bushing to ground

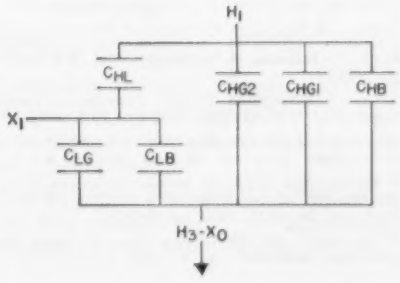

Fig. 10. Equivalent capacitance diagram of a transformer winding of one phase of a 3-phase core-type transformer.

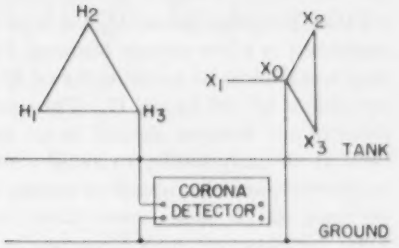

Fig. 11. Transformer connections for corona tests.

It is clear from this diagram that if there is a disturbance in the high-voltage winding, there will be current flow through a number of parallel paths to ground. In general, C_B is quite large, and C_{HG1} is also quite large. C_{HG2}, being the series capacitance of the entire high-voltage winding will be somewhat low for an ordinary core-type transformer, but may be high for a shell type. C_{HL} is of special interest, because it may introduce disturbance from the low-voltage winding through the capacitance from the high- to low-voltage windings. For this type of transformer, it is obvious that detection can be determined through the ground connections either through the tank as a whole or through the bushing, or the entire high-voltage winding. In order to check this, the pulser described earlier was connected through a 96.6-$\mu\mu$f capacitor to the tank, and to the terminal of the high-voltage winding.

Referring again to Fig. 10, it is seen that disturbances from the outside are reduced to those transmitted chiefly

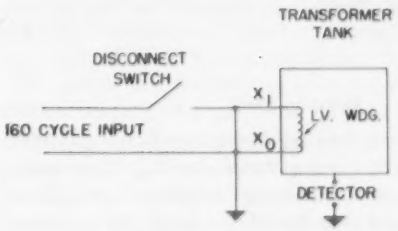

Fig. 12. Connections for test to determine effect of corona disturbance incoming from low-voltage excitation.

through the capacitance from the low- to high-voltage windings. Hence, all tests were made with the low-voltage winding grounded separately.

The following calibration tests were made with connections as shown by Fig. 11: pulser connection on tank, detector between tank and ground, sensitivity 1.035 millivolts per $\mu\mu$coulomb; pulser on H_1, H_2 connected to tank, detector between tank and ground, sensitivity 0.88 millivolt per $\mu\mu$coulomb; pulser on H_1, H_2 connected to tank, tank grounded, detector between bushing tap plug and ground, sensitivity 0.34 millivolt per $\mu\mu$coulomb.

Since the quantity of charge added each time from the pulser circuit is the same and was known, the relative sensitivities give the proportion of charge transmitted to the detector circuit in each case. For this particular case, it is obvious that the tank and bushing tap plug are advantageous points and that the tank is the best.

In order to check the transmission of disturbance from

the low-voltage winding, the incoming lines were excited with a disconnect switch in one line and the other line connected to a low-voltage bushing, Fig. 12. The disturbance was seen to be in the order of 40 μμcoulombs at the equivalent of 100 kv on H_1. This means that the sensitivity of the detector should be set to give small deflections at 40 μμcoulombs, to avoid confusion with incoming disturbances. Inasmuch as corona in oil based on the previous test is more severe than this (approximately 3,000 μμcoulombs) and it is nearly all detected if it originates in the transformer, this sensitivity should detect any internal corona in oil.

The transformer was excited on X_1, X_0 with H_1 at various voltages and H_2 grounded. At 65 kv disturbance appeared. This was measured at the tank to ground. Values at 65 kv, 70 kv, and 80 kv were 60, 140, and 200 μμcoulombs, respectively. A large ball was added to the top of the H_1 bushing, and the corona level was increased to over 120 kv, showing that this disturbance originated at the bushing cap.

Tests were made on other units and, disregarding corona below the level of a few hundred μμcoulombs, there was no corona in the oil. It is to be noted that these tests were made at 160 cycles, and the circuit used in the detector and this frequency combined together tend to eliminate disturbances in the shop to levels making it possible to make these tests.

Caution should be observed in making tests of this nature on high-voltage equipment. The detection equipment is normally at ground potential, but if there is a breakdown to the transformer tank, high transient voltages will exist between the corona detection equipment and other grounds. Proper precautions in this respect can be taken.

CONCLUSION

A CIRCUIT has been devised which can make quantitative measurements of corona. Some data has been taken on the magnitude of disturbances in voids and samples in oil, which indicate that the disturbances are relatively large. Also, disturbances in air in concentrated fields seem to be low, making discrimination between them possible. Tests on equipment have been made confirming these conclusions. With proper discrimination between external corona in air and internal corona in voids and corners under oil, it is possible to make quantitative tests on oil-insulated transformers. In addition, such measurements, not previously possible, may be made on capacitors and large capacitances.

Appendix

Mathematical Analysis of the Detector Circuit

The circuit is described in several mathematical texts. It comprises two circuits with capacitance, inductance, and resistance, with some coupling or mutual inductance. If the various constants can be expressed as L_1, C_1, R_1, and M for the primary, and as L_2, C_2, R_2, and M for the secondary, the circuit equation for the current in the secondary is

$$i_2 = \frac{-E_1 M p}{\left[L_1 p + R_1 + \frac{1}{C_1 p}\right]\left[L_2 p + R_2 + \frac{1}{C_1 p}\right] - M^2 p^2}$$

For this equation to be valid, the voltage E is considered to be a pulse, and to be equivalent to the change in potential resulting from the short circuit of a small capacitance in series with C_1. This, in turn, physically results from the increase in capacity in C_1 due to the breakdown of a void. It, in turn, necessitates the definition of corona as the instantaneous breakdown of a part of the dielectric circuit.

The solution of the foregoing equation is difficult if the resistance is included. However, this equation can be transformed to

$$i_2 = \frac{-E_1 M C_1 C_2 p^3}{(L_1 C_1 p^2 + C_1 R_1 p + 1)\ (L_2 C_2 p^2 + R_2 C_2 p + 1) - M^2 C_1 C_2 p^4}$$

In turn

$$E_2 = \frac{i_2}{C_2 p}$$

Therefore

$$E_2 = \frac{-E_1 C_1 M p^2}{(L_1 C_1 p^2 + C_1 R_1 p + 1)\ (L_2 C_2 p^2 + R_2 C_2 p + 1) - M^2 C_1 C_2 p^4}$$

$E_1 C_1$ is equal to the quantity of electricity in coulombs in the primary circuit, and the terms in p, of course, represent the damping and oscillatory terms in the solution.

The solution using typical values has been made, and shows that, depending on the secondary resistance, an almost instantaneous rise in secondary voltage can occur, or that the exponential increase shown can occur. This latter occurs when the secondary resistance is low, or there is some feedback from an amplifying circuit. In this analysis, it will be observed that the magnitude of the primary capacitance is not of vital importance.

In other words, the quantity of electricity in any disturbance is measured directly, and it is possible to measure it even with large values of capacitance. Hence, in this application, unlike some others, the measurement of the disturbance in capacitors, etc., is possible. Also, considering the transformer to be a capacitance only, disturbances anywhere in its structure will be detected, although the sensitivity may be slightly changed depending on its location. It is not necessary to consider the changes due to oscillations within the winding itself which are of much lower frequency.

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Circuits with D-C Magnetization and High Induction

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CRITERIA have been established, on the basis of a fairly simple theory, for analysis or design of magnetic circuits in which there are an unbalanced or d-c magnetization and a high alternating induction. High values of alternating induction and a nonlinear relation between induction B and field strength H are characteristics of magnetic circuits in power apparatus, in contrast to magnetic circuits in audio components.

The relation between induction and field strength during cyclic variation is given approximately by the d-c magnetization curve of the magnetic circuit. Maximum and minimum values of induction correspond to maximum and minimum values of field strength, respectively, but the average values of B and H are not simply related because of the nonlinearity of the magnetization curve.

A simple circuit has been devised for obtaining data on magnetic-core samples by direct measurement. This circuit requires two windings on the test sample and an auxiliary transformer with two windings having the same turns ratio as those on the test sample. Primaries and secondaries of test sample and auxiliary transformer are connected in parallel. An a-c voltage is applied in parallel with the primaries; and a d-c voltage is applied in series with the secondaries. This arrangement is similar to two parallel-connected saturable reactors. Sample characteristics, core loss (plus primary copper loss, if appreciable), and exciting current may be directly measured with meters placed in the primary circuit.

The significant variables for a core sample subjected to essentially sinusoidal flux variation are: the alternating component of flux density B, the field strength H_{dc} averaged both in time and in magnitude around the magnetic circuit, and the effective nonmagnetic gap as a percentage of magnetic circuit length. Average flux density is not a useful parameter and is very difficult to measure in a closed magnetic circuit undergoing cyclic variations. Typical test results for one value of alternating flux density B and several values of average field strength and per cent effective nonmagnetic gap are given in Fig. 1. The sample is a wound-type core of 12-mil grain-oriented silicon steel with two butt joints, and weighing 1.5 pounds. The lower envelope of curves of Fig. 1 corresponds to the values of gap, at each value of field strength, which give maximum inductance of a choke or minimum exciting current of a transformer. From data similar to Fig. 1, design curves have been compiled for a range of flux densities. Fig. 2, for the same core sample, gives excitation (a-c component only) in volt-amperes per pound and the gap which yields minimum excitation as functions of a-c flux density and average field strength. Core loss is also a function of these two variables.

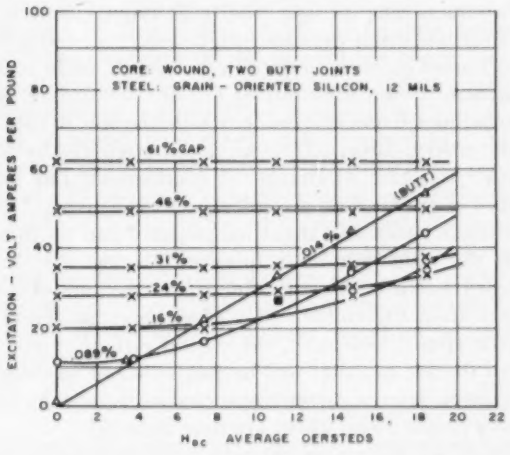

Fig. 1. Excitation of wound core at 80 kilolines per square inch (60 cps).

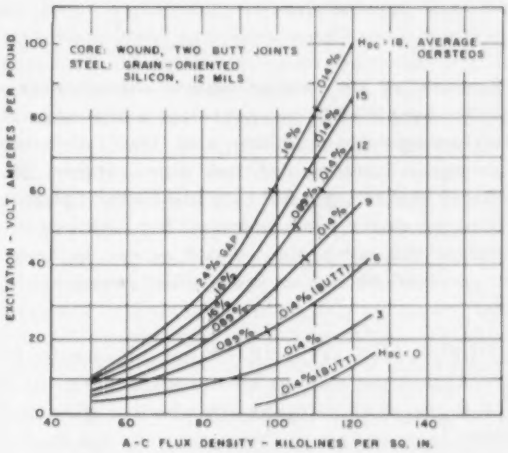
CORE: WOUND, TWO BUTT JOINTS
STEEL: GRAIN-ORIENTED SILICON, 12 MILS
H_{dc} = 18, AVERAGE OERSTEDS
EXCITATION - VOLT AMPERES PER POUND
A-C FLUX DENSITY - KILOLINES PER SQ. IN.

Fig. 2. Excitation and gap for wound core—design curves (60 cps).

The data on magnetic materials are applicable to reactors, and to transformers with unbalanced direct current such as those for supplying half-wave rectifiers. Analysis of the frequency components aids in understanding the operation of the half-wave supply circuit. Only the induced voltage of the primary winding and the average secondary current affect the magnetic circuit.

Digest of paper 57-599, "Magnetic Circuits with D-C Magnetization and High Alternating Induction," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Technical Operations Department for presentation at the AIEE Great Lakes District Meeting, Des Moines, Iowa, Apr. 15-17, 1957. Scheduled for publication in AIEE *Communication and Electronics*, July 1957.

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The Use of SF_6 for High-Power Arc Quenching

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Because of its electronegative characteristics, sulfur hexafluoride gas possesses a phenomenal arc-extinguishing ability and high dielectric strength. Experimental test data support the theory that this gas not only is a better dielectric than air at the same pressure, but also can interrupt the same short-circuit power as compressed air and at lower blast pressures.

SULFUR HEXAFLUORIDE gas (SF_6) has found application not only as an unusually good dielectric but also as an exceptionally effective arc-quenching medium. Investigation of these properties has resulted in development testing involving the interruption of short-circuit currents far beyond values reported in previous papers.[1-3] The arc-extinguishing effectiveness of SF_6 can be attributed to its electronegative characteristic, which causes it to absorb free electrons in an ionized gas column with extreme rapidity.

At the 1956 AIEE Fall General Meeting, C. F. Cromer and R. E. Friedrich presented a paper[4] describing an SF_6 circuit breaker capable of interrupting currents as high as 5,000 amperes at 115 kv. Gas flow through interrupting gaps was established by the expansion of gas heated by the arc at adjacent pressure-generating gaps. In this paper, two outstanding experimental prototypes for high power arc interruption are described. A cross-blast and arc-splitter arrangement successfully interrupted currents up to 74,000 amperes at 13.2 kv with SF_6 gas under 60 psig (pounds per square inch, gauge) pressure blasting to atmosphere. The other device, with a 10-inch diameter puffer producing gas flow through an orifice in a totally sealed chamber, was demonstrated to be capable of interrupting the full capacity of the test laboratory at voltages from 22 kv to 132 kv. Contamination of the gas by arcing produced no appreciable loss of dielectric strength, and active gas impurities were shown to be easily removable.

THEORY

UNDERSTANDING of the fundamental basis for the a-c arc-quenching effectiveness of SF_6 gas still lags somewhat behind the ability to use it, but significant progress is being made in developing an adequate theory. In general, the exceptionally strong tendency for free electrons in this gas to be captured to form relatively immobile negative ions is believed to underlie its phenomenal extinguishing ability as well as its superior dielectric strength. Research work[5] on negative ion formation in SF_6 has been done and is being continued with the aid of a mass spectrograph. These studies indicate that electrons are captured to form mainly SF_6 and SF_5 ions, both of which are very massive and, hence, relatively ineffective as current carriers. Although electric breakdown and arc quenching are both strongly affected by this electron trapping, these two phenomena are so different in detail that the effects observed are quantitatively quite different. Plain-break contacts drawing 60-cycle arcs in SF_6 can interrupt 100 times as much current as similar arcs drawn in air, even though sparking voltages in SF_6 are only about 2.4 times those in air.[1]

For quenching a-c arcs, the basic requirement of the gas medium is not primarily high dielectric strength but high rate of recovery of dielectric strength, or in roughly equivalent terms, high rate of loss of conductance as the alternating current reaches zero and attempts to continue in the reverse direction. As suggested originally by A. M. Cassie,[6] this rate of change of conductance can be described in terms of an arc column "time constant." From a physical viewpoint, this time constant can be thought of as the ratio between a quantity proportional to the energy content of the arc column and the rate of loss of energy from the column at a given moment. From the electric circuit viewpoint, the critical rate of voltage rise across the arc gap that will be just sufficient to cause arc re-ignition after a current zero can be shown[7] to be inversely proportional to the arc time constant.

Means for aiding arc extinction generally serve to increase the rate of energy loss from the arc column. When a gas blast is used, Cassie[6] has indicated that the energy loss can be divided into two main processes: (1) convection loss resulting from the deformation or shrinking in diameter of the conducting arc path, which occurs in rapidly accelerated gas flow; and (2) diffusion loss of heat and ionization radially outward from the arc column to its immediate surroundings.

As an exploration of comparative arc behavior mainly involving the diffusive type of loss, experimental studies of the dynamic arc time constants of small d-c plain-break arcs in various gases at atmospheric and higher pressures have been made in an effort to throw more light on the critical quenching processes for higher current a-c arcs in gas blasts. Preliminary results have yielded striking correlation between the relative values of arc

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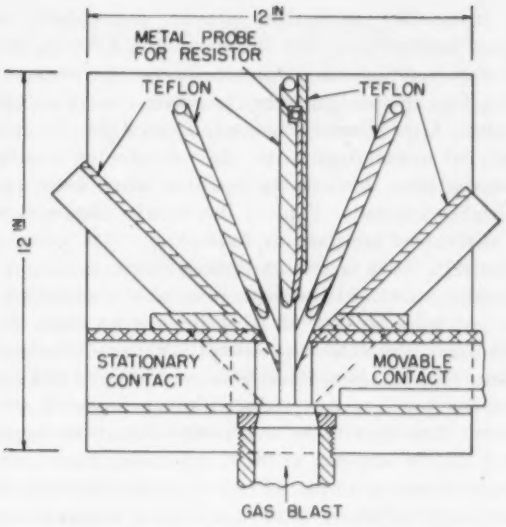

Fig. 1. Schematic section of cross-blast breaker.

time constants in air and in SF_6 and the current interrupting limits at a given circuit voltage for plain-break 60 cycle arcs in these two gases. For low-current arcs in air, observed time constants are near 100 microseconds, whereas in SF_6 they are about 1 microsecond.

Because of this ability of SF_6 to respond extremely rapidly to changing conditions, the necessary flow-producing effort to make the arc diameter follow closely the falling current magnitude as it approaches zero is relatively so small that the pumps required may be described as mere "puffers." In certain cases, these can even be replaced by simple expansion chambers powered only by arc heat. Experiments, to be described, illustrate the effectiveness of relatively low driving pressures for interrupting moderate current a-c arcs in SF_6. At the highest currents interrupted, the required flow-producing pressures for arc extinction are only one third to one half the values for air.

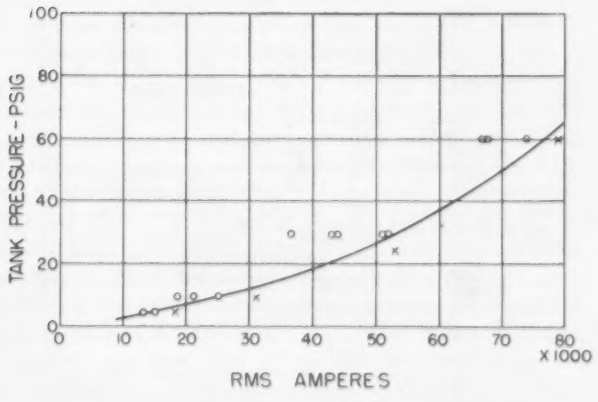

Fig. 2. Performance of cross-blast breaker with resistance shunt at 13.2 kv. (O = Successful operations, X = Failures.)

CROSS-BLAST BREAKER

One experimental arrangement used to explore the interrupting effectiveness of SF_6 gas for large alternating currents is shown schematically in Fig. 1. Three diverging arc splitters made of polytetrafluoroethylene (Teflon) were mounted above a rectangular gas discharge opening supplied from a storage tank through a blast tube provided with a quick-acting valve. Inverted U-shaped openings in the splitters permitted passage of a heavy copper contact into and out of stationary finger contacts. A copper-tungsten-tipped probe and contact was mounted on one side of the middle splitter with its exposed tip just above the central opening as shown. A compressed air mechanism was used to close or withdraw the moving contact. Instantaneous gas pressures within the splitter openings were recorded with a telemeter gauge.

The results of one series of tests of this breaker in a 13.2-kv reactive circuit are plotted in Fig. 2. A noninductive resistor of only a few ohms was connected between the probe electrode and the stationary contact. With this arrangement, 15,000 amperes could be interrupted with only 5 psig gas pressure. With 60 psig pressure, a 74,000-ampere current was successfuly interrupted. This is equivalent to the interruption of 3,000 mva in a 23-kv

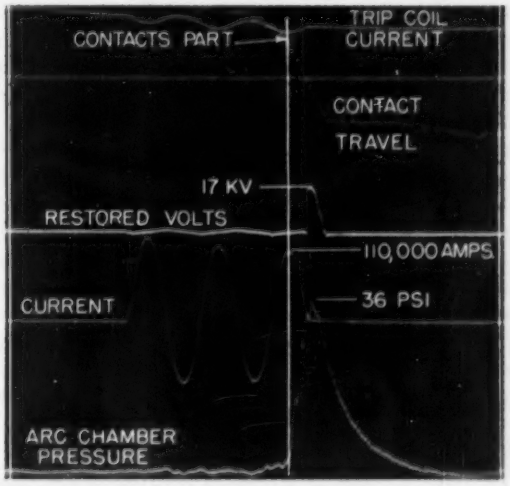

Fig. 3. Oscillogram of 74,000-ampere interruption at 13.2 kv by cross-blast breaker with resistance shunt.

grounded-neutral 3-phase circuit (or 2,000 mva at 15 kv ungrounded). In the oscillogram of the 74,000-ampere test, Fig. 3, the peak gas pressure within the arc box is shown to have been only 36 psig.

One of the most striking observations in testing this cross-blast breaker with SF_6 was the small amount of visible flame discharged, compared with the performance of such arrangements using compressed air. It may be noted in Fig. 1 that no flame suppressors whatsoever were used, and the splitters had a length beyond the arc-contacting edge of only 7 inches. In spite of this construction, no failures ever occurred because of flashover beyond the

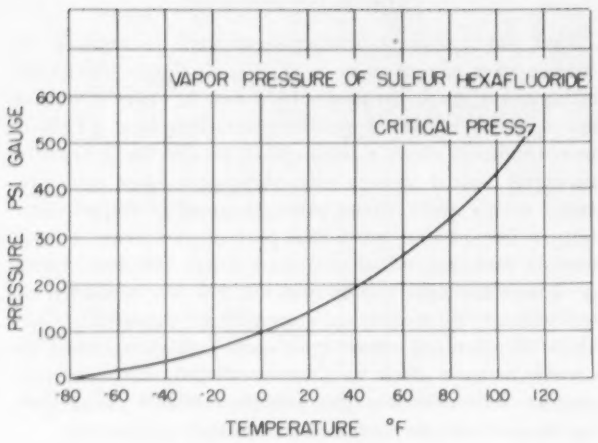

Fig. 4. Vapor pressure of SF_6 as a function of temperature.

splitters when using SF_6. With air, flashover would occur at a very low power level. Tests with SF_6, not using the shunt, were extended to voltages as high as 44 kv interrupting up to 10,000 amperes, still with no external flashover. This performance was another demonstration of the extraordinary rate of recovery of dielectric strength by SF_6 gas after arcing.

Despite the rather amazing performance of this cross-blast breaker in terms of power interrupted for so small an arc box, it is evident that such a device, in discharging directly to the atmosphere, would be wasteful of the somewhat expensive gas. At a cost of 10 cents a gallon per atmosphere pressure, 3-pole operation would involve the expenditure of several dollars worth of gas. Also, there would be some hazard in disposing of a gas which contains toxic components after it is heavily arced. Another problem to be considered in connection with the storage of SF_6 at, say, 100 psig, would be the need for a heater on the reservoir to avoid liquefaction and loss of pressure if the ambient temperature should fall below 0 F. A vapor-pressure curve for the SF_6 as a function of temperature is shown in Fig. 4.

HIGH-POWER PUFFER BREAKER

The disadvantages of a breaker blasting to atmosphere can be avoided by using a piston to provide gas flow only when needed in a completely sealed interrupting chamber. Studies of SF_6 interrupters indicate that much lower gas flow velocities are required than for air blast breakers, thus making the use of puffer-type designs appear practical even for fairly high-power arc quenching. Furthermore, the excellent dielectric strength of the gas makes it unnecessary to maintain high gas pressures for insulating purposes. This type of interrupting device can be simple in design and, since the gas is compressed only during interruption, operation is obtained without condensation even at very low ambient temperatures. The test breaker prototype shown in the schematic section view of Fig. 5 was built to study high-power interruption. The orifice and the moving contact were both attached directly to the puffer piston and moved with it.

A hydraulic mechanism proved particularly well-adapted for operating this interrupter. A 2,000-psi system with a piston-type accumulator for energy storage was used, giving adequate driving force with a small operating cylinder. Approximately constant speed of the puffer could be maintained with this system, providing a strong gas blast through the arc even when interrupting the higher currents. Typical test results obtained with this interrupter are given in Table I.

The tests, with a few exceptions, were made on unshunted reactive circuits, with rates of rise to over 2,000 volts per microsecond. It is of interest to note that a single break was able to interrupt 7,500 rms symmetrical amperes (the maximum available current) at 132 kv even when the pressure was reduced to atmospheric in the breaker. The maximum available current of approximately 17,700 amperes at 66 kv also was interrupted at pressures down to 15 psi. In order to raise the current interrupting limit above 25,000 amperes, it was necessary to reduce the rate of voltage rise with this interrupter. Tests 12 and 15 in Table I show that the limit could be raised to over 40,000 amperes, with a rate of rise of 300 volts per microsecond and a chamber pressure of 45 to 60 psi.

Tests 16 to 24 show the performance of a modified design having a slightly larger orifice. It is to be noted that with this interrupter the maximum available current of 22,300 amperes at 44 kv was easily interrupted at 2,300 volts per microsecond rate of rise. At 22 kv, the maximum available symmetrical current of 43,000 amperes was also interrupted, with 1,560 volts per microsecond rate of rise. On the other hand, a repeat test result in a failure to interrupt, indicating that a limit had been reached. However, since these rates of rise are much higher than are usually encountered when interrupting short circuit currents of this magnitude, the circuit was shunted in the last test of Table I to give a rate of rise that might be expected per single interrupter break in actual service. At 260 volts per microsecond, interruption of 41,800 amperes was easily accomplished with only one-half cycle of arcing.

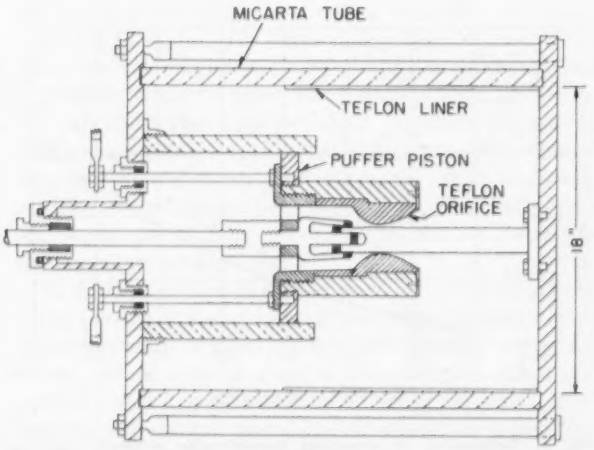

Fig. 5. Schematic view of puffer-type SF_6 interrupter.

SPECIAL PROBLEMS WITH SF_6

STUDIES OF DECOMPOSITION of SF_6 from arcing indicate that such a large amount of arc energy is required to decompose a cubic foot of the gas at atmospheric pressure that 100 or more high-power interruptions can be made in the gas before even this relatively small volume would be decomposed.

The gaseous decomposition products are believed to be chiefly lower fluorides of sulfur, and are readily removed by absorption in activated alumina. The used-up gas may then be replaced, but actually the reduction in pressure is so negligible that this need seldom be done. For a 1,000-mva 115-kv SF_6 breaker filled to 45 psig, it is estimated that the absorption of the decomposition products from 50 interruptions at full-rated short-circuit current of 5,000 amperes would reduce the chamber pressure by only 1 psi. For the high-power interrupter used to obtain the data of Table I, it is estimated that over ten 40,000-ampere interruptions could be made per pound of pressure drop.

Table I. Test Results with Sealed Puffer-Type Units in SF_6 Gas

Test Number	Circuit Kilovolts (Nominal)	RMS Amperes	Arc Chamber Pressure, psig	Arcing Time, cycles	Rate of Rise, volts per microsecond
1	132	7,350	45	0.8	1,840
2	132	7,700	15	1.25	2,120
3	132	7,500	0	1.8	2,120
4	66	5,870	15	0.5	2,120
5	66	8,300	15	0.8	2,000
6	66	16,800	30	1.1	1,900
7	66	17,700	15	1.75	1,700
8	44	19,500	30	1.3	1,140
9	44	21,000	45	F>3	1,200
10	22	21,600	15	1.25	780
11	22	24,400	15	F>3	800
12	22	25,700	30	1.0	363
13	22	33,800	60	1.0	383
14	22	43,200	45	1.25	208
15	22	41,800	60	1.1	290
		Modified Design with Larger Orifice			
16	44	10,300	44	0.2	2,020
17	44	16,700	44	0.6	2,180
18	44	22,300	55	0.7	2,320
19	22	21,300	55	0.7	1,275
20	22	31,200	55	0.95	1,425
21	22	36,300	60	1.1	1,460
22	22	43,300	60	1.0	1,560
23	22	42,000	60	F>1.3*	1,560
24	22	41,800	55	0.5	260

F–Failures. Arcing time limited to values shown by back-up breaker.
* Back-up breaker abnormally close.

One obvious method of operating the contacts in a pressure-filled gas breaker is to use the compressed gas itself as the energy source. This is generally not practical in SF_6 breakers because: first, the gas pressure is so low that the operating piston becomes large; second, the high density of SF_6, five times that of air, reduces the acoustic flow velocity to about one half that of air and thus requires large ports and shorter piping; and third, the cost of the gas, if exhausted to atmosphere from the operating cylinder, would be considerable. A separate source of energy for contact and puffer operation, therefore, seems desirable and was used in the breaker prototypes described here.

Inasmuch as the SF_6 gas should be reasonably pure and dry, circuit-breaker chambers need to be evacuated and then filled to the desired pressure from an SF_6 gas cylinder. A high vacuum, however, is not necessary, because a purity of gas of 99% is quite satisfactory, and an admixture of dry air up to several per cent can be tolerated without appreciable loss of interrupting ability. In case of necessity, it is possible, though less economical, to fill a breaker chamber by simply displacing the air, admitting the heavy SF_6 gas at the bottom of the chamber, and venting the air at the top.

Although the unarced SF_6 is extremely stable and nontoxic, some decomposition products formed by arcing are toxic, and reasonable care must be exercised in servicing the breakers. Fortunately, these products have a strong odor, giving ample warning of their presence. The proper use of activated alumina can remove almost all of these decomposition products, and thus practically eliminate any hazard caused by their toxic nature. In addition to the active gases, there are also some metallic fluorides formed from reaction with the contacts during arcing. These fluorides, which distribute themselves as fine powder throughout the breaker chamber, have high resistivity and cause no electrical troubles. They may be removed readily during servicing by vacuum cleaning or by air blast. Although this dust is not highly toxic, a dust mask is recommended to prevent inhaling it during breaker servicing. It is of interest that no injury has occurred to personnel during several years of experimentation with these breakers.

CONCLUSIONS

THE EXPERIMENTAL TEST DATA given supports the statement that SF_6 gas not only is a better dielectric than air at the same pressure, but also can be used to interrupt just as high short-circuit power as with compressed air and at considerably lower blast pressures.

However, the high cost of SF_6 compared to air and the need for disposing of the discharged gases make its use undesirable in blast-type breakers exhausting to atmosphere. On the other hand, closed systems which are arranged to pump the gas through the arc without noise or external demonstration show promising results, and further development may be expected to yield high-voltage breaker designs with moderate to heavy rupturing capacity that should be commercially feasible.

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Transfer Function of Contact-Modulated Amplifiers

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MOST, IF NOT ALL, of the theory of carrier systems for d-c amplification has been based on the use of sinusoidal modulators. In general, this approach has been adequate for showing the equivalence of such systems to direct-coupled systems in many steady-state and transient characteristics. Such analyses are only applicable to contact-modulated systems in the broadest sense, however, and completely fail to indicate special types of transfer functions arising from the unique properties of the contact modulators.

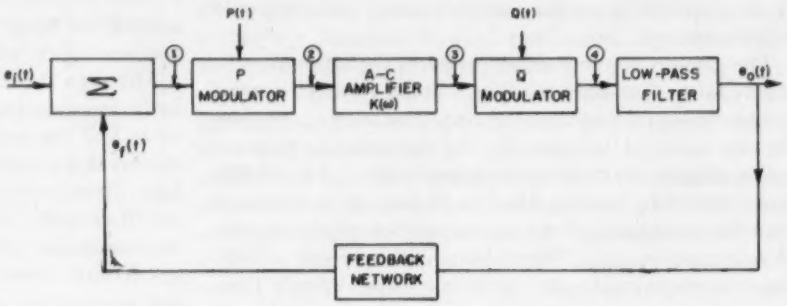

Fig. 1. Block diagram of a contact-modulated feedback amplifier.

The amplifier selected for study was a low-level instrument amplifier, a block diagram of which is shown in Fig. 1. In this configuration, the error signal at point 1 is chopped by the *P* modulator, producing essentially square-wave signals at the input terminals of the a-c amplifier. The modulated signal is amplified as much as 40 million times and synchronously demodulated. The low-pass filter restores the signal to its original waveform by removing modulation by-products. A fraction of the resulting output signal is fed back to the input for gain stabilization.

If the frequency of the input signal is very low compared to the carrier frequency, the system is superficially equivalent to a direct-coupled amplifier. For higher frequency input signals, no such simple situation exists and families of transfer functions must be computed. In general, it was found that the transfer functions are dependent upon the frequency response of the a-c amplifier, the filter characteristics, and the percentage conduction time of the modulators and their relative phasing. The degree of asymmetry in each modulator was found to be a particularly important factor.

The transfer functions specifically studied were those of the forward path (point 1 to the output). This is permissible because of the purely resistive feedback path and the well-known relationships between open-loop and closed-loop frequency response. The characteristics of the output filter, although practically of great importance, were idealized to focus attention on the combination of amplifier and modulators.

One transfer function of interest is the case where each chopper produces ideal square-wave modulation. The fundamental chopping frequency is ω_o. The phase shift between modulators is zero. The a-c amplifier is characterized by a poor low-frequency response because of the resistance-capacitance interstage coupling. Its low-frequency gain is down 3 db at frequency ω_c.

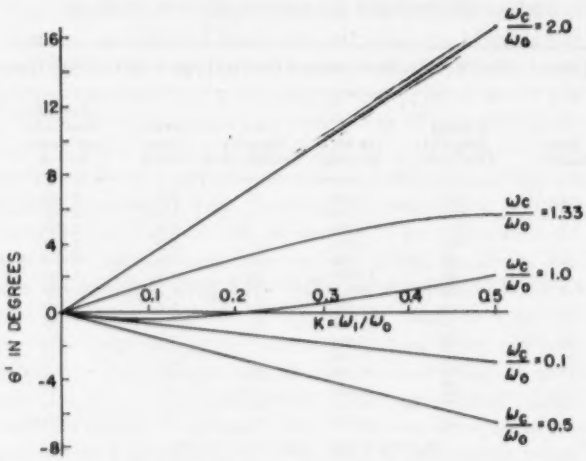

Fig. 2. Forward transfer function with ideal full-wave modulators (phase characteristic).

The amplitude characteristic for this case is essentially independent of the signal frequency ω_i but strongly dependent on the a-c amplifier bandwidth. Maximum gain is obtained at low values of ω_c.

The phase characteristic (Fig. 2) plots the phase angle of the forward transmission against input signal frequency. For wide-band a-c amplifiers ($\omega_c/\omega_o = 0.1-0.5$), the phase angle is lagging for all signal frequencies. If the bandwidth is narrowed, the phase angle becomes positive and increases linearly with signal frequency in the region $\omega_c/\omega_o = 2$. The phase shift to a d-c signal is, of course, zero in all cases.

This is but one of several families of functions obtained from the study of contact-modulated amplifiers. Others, showing the effects of phase shift and asymmetry in the modulators, are illustrated in the paper.

Digest of paper 57-204, "A Study of the Transfer Function of Contact-Modulated Amplifiers," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 21-25, 1957. Published in AIEE *Applications and Industry*, Mar. 1957.

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Dynamic Gauging and Automatic Adjusting of Relays

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THE GAUGING AND ADJUSTMENT of the contact operate points of the Bell System's wire spring relay[1,2] will be considered in this article. It is clear that if relays are to perform their function of making and breaking electric circuits rapidly, reliably, and in the proper sequence, it is necessary to specify a range or ranges within the armature's total travel within which all the contacts must operate. Presently, the gauging is done on a purely "go, no-go" basis using thickness gauges to displace the armature to the specified limits, say 0.007 and 0.016 inch, and then ascertaining the contacts' state. This method provides a satisfactory, but not necessarily optimum, adjustment.

The armature velocities on the operate stroke for all relays of a given code are approximately the same. Therefore, it is possible to determine the contact gauging distance by measuring the time interval between the instant of contact operation and the instant that the armature reaches the end of its travel, and multiplying this by the known armature velocity. Fig. 1 outlines the operation of a developmental dynamic gauging and automatic adjusting device using this idea. The relay under test is electrically operated. The operation of the individual contact being gauged opens an electronic gate and allows pulses to pass through to an electronic binary counter until, at some time later, the armature reaches the end of its travel and the gate is closed by a stop pulse. This stop pulse is derived by an *RC* network which differentiates the relay coil current, and results from the sharp discontinuity which occurs in the relay coil current when armature motion ceases. The number of pulses registered is a measure of the time required for the armature to travel through the gauging distance and, therefore, if the correct pulse source frequency is used, this number of counts is a direct indication of the actual gauging distance. The interpreting unit compares the number of counts actually registered with the number of counts that would have been registered had the gauging distance been within established limits.

The adjustment of the contact operate points is accomplished by placing an adjusting bit, Fig. 2, in a slot of the supporting member for the center row of contacts

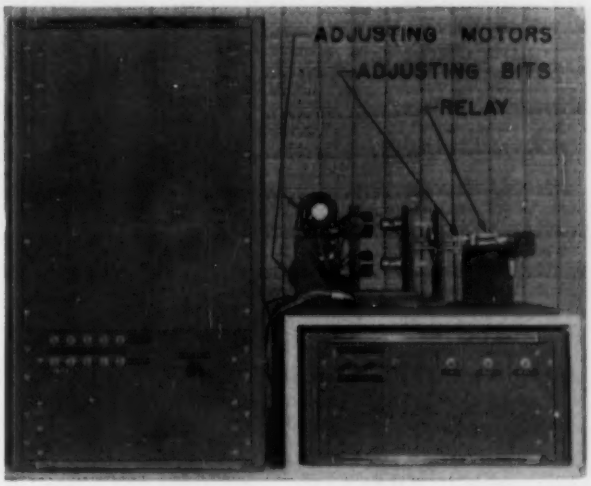

Fig. 2. Experimental gauging and adjusting facility.

and permanently deforming this arm so that the contacts assume the new desired position. By controlling the length of time that the synchronous motor torque is transmitted to the adjusting bit, the permanent deformation may be accomplished in steps of approximately 0.001 inch. With this experimental device, it is possible to adjust the operate points simultaneously for the two extreme end contacts of the relay to mid-range or optimum. By virtue of the relay design, if the extreme end contacts are adjusted to optimum so will the other contacts be near the optimum for most relays.

The method outlined does not require the precise positioning of the relay under test relative to a sensing device. It does not require any physical loading of the armature and, consequently, is a truly dynamic test since test conditions are similar to actual field operating conditions.

Specifically, a new experimental approach to the gauging and adjusting of relays has been presented. It is apparent, however, that this same general gauging method may be applied to the measurement of dimensional characteristics in other fields.

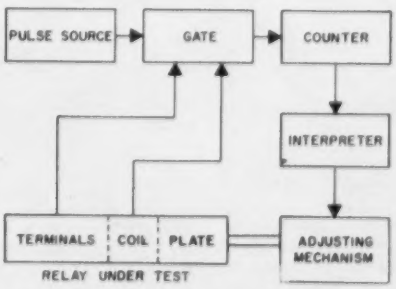

Fig. 1. Dynamic gauging and automatic adjusting.

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Current Density and Temperature of High-Current Arcs

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DURING INTERRUPTION of high-current arcs in circuit breakers and contactors, the region between the contacts must be converted from an intensely hot conducting medium to a relatively cool insulating medium. Although the cooling of low-current arcs has been explained by means of conduction, free convection, and radiation, extension of these mechanisms to relatively short (2- to 3-inch) high-current arcs accounts for no more than 25% of the total electric energy input. The purpose of this article is to present a theory, physical picture, and supporting data to explain the cooling process in a high-current (10,000- to 20,000 ampere) free arc.

This article depends upon and extends the work of two previous articles of this same series on high-current arc and interruption phenomena. In the first of these,[1] arc current distribution was measured for the first time, revealing both a bell-shaped curve of distribution along the radius, and the fact that most of the current flows outside of the most highly luminous regions. In the second article,[2] contact erosion characteristics of various metals were determined, showing that ambient atmosphere may be displaced by vaporization of electrode material.

The first step in the present investigation was to verify by a new measuring method the earlier current-density measurements. This was done because the results had been so unexpected and were so basic to the development. In the new method, a tiny window-type air-core current transformer was placed in the arc plasma to link a fraction of the total arc current. Only one side of the transformer was immersed in the arc, and this was encased in a thin graphite tube. By positioning the transformer at various radii from the center of the arc, the complete distribution of current was obtained. From the current distribution, the current density for any given radius can be calculated. The current density at the center of a 17,000-ampere arc was found to be 4,000 amperes per square centimeter, in good agreement with the previous measurements.

The next step was that of determining the approximate temperature distribution. Recent advances in mathematical physics were applied to find a relationship between arc resistivity, temperature, and electron density. Combining this relationship with the well-established Saha's equation, which relates temperature to electron density, yields a temperature at the center of the arc of approximately 19,000 K (degrees Kelvin).

This high temperature was the key to the understanding of the primary mechanism of heat dissipation. At this temperature, practically all of the atoms in the arc column have lost at least one electron. This process of ionization requires a very large amount of energy. At any one instant, the total heat and ionization energy stored within the current-carrying plasma is only a few per cent of the total electric energy input in one half cycle. However, the electrodes continually are being vaporized as jets. This material momentarily becomes the arc column and is, therefore, ionized. It is then displaced by some additional freshly vaporized electrode material and is blasted out through the boundaries of the arc, carrying the stored ionization energy with it. As an example,[2] a 10,000-ampere arc held between copper electrodes for 1/120 second will vaporize about 0.75 grams of copper from two electrodes. To heat this amount of copper to 20,000 K as it flows through the arc requires 8,500 watt-seconds of energy, including that necessary for excitation and ionization. For a 2-inch long, 10,000-ampere arc, the total electric energy input is about 10,000 watt-seconds. Thus, the proposed cooling mechanism is of the right magnitude to account for the electric energy input.

For shorter arcs, it is postulated that some of the vapor escapes ionization, and for longer arcs, turbulence draws in some of the surrounding gases for ionization. The process by which the energy is transferred from the arc column to the jet column is of the same type as the jet mixing studied by aerodynamicists. In the arc, the unique features are: (1) a cool jet (3,000 to 5,000 K) flows into a hot medium (20,000 K) rather than vice versa and (2) high absolute temperatures are involved. It is believed that the flow in the mixing region is turbulent and the rate of heat transfer is, therefore, very high.

It is not implied that high erosion of contact material is the mark of an efficient interrupter. In using oil, fiber, and arc chutes in circuit breakers and contractors, and expulsion tubes in fuses, the designer has provided other materials for the arc to vaporize, ionize, and expel in the cooling process. With compressed-gas breakers, the vaporization is not needed to produce the mass flow, but the cooling is again accomplished by heating, ionizing, and removing gas.

Two of the aims of this series of investigations are to clarify physical pictures and to obtain basic data which can be used in applying basic thermodynamic and fluid flow equations, together with computers, in developing and designing the various types of circuit interrupters.

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Early Electrical Machines

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This is the fifth article of a series on pioneering investigations in electrical science. Some further history on the development of the lightning rod is given along with an account of the Van Marum machine, the largest electrostatic generator built in the 18th Century.

IN ENGLAND, the efforts to repeat Franklin's experiments were generally unsuccessful because of the infrequency of thunderstorms and the relatively high humidity. However, Canton on July 21, 1752, did succeed in drawing a half-inch spark which he distinctly saw. Watson repeated the lightning rod experiment and reported its results to the Royal Society in December 1752. In Russia, Professor G. W. Richmann, a Swedish physicist of the Imperial Academy of St. Petersburg, in attempting to duplicate the experiment of Dalibard, was killed on August 6, 1753, when lightning struck his apparatus which was not grounded. A spark nearly a foot long leaped from the insulated rod to his head. He thus became the first martyr in the new science.

This unfortunate occurrence did not prevent the Russian scientist Prince Gallitzin from undertaking an extensive study of atmospheric electricity beginning in 1775. Using a kite, he concluded that some electricity was present in the atmosphere at all times and in any kind of weather conditions.

What was intended by Franklin to be a confirmation of the hypothesis of the identity of electricity and lightning provided mankind with the lightning rod, a device for avoiding the destructive results of lightning strokes, and considered one of the important inventions of the 1700s.

While the "Philadelphia experiment"—the term used for testing Franklin's lightning rod—was being tried in England and on the continent, Franklin provided another experimental proof as to the similarity of electricity and lightning. This was the famous kite experiment. The exact date of the experiment itself has not been established with certainty; it probably was made some time in June 1752 and, chronologically, it followed Dalibard's erection of the lightning rod, which Franklin also devised. An account of the kite experiment was published in London in December 1752. At this same time (June or July 1752), we learn from Franklin's later reports, pointed rods for lightning protection had already been erected at the Academy (now the University of Pennsylvania) and the State House in Philadelphia. Franklin's own Philadelphia house was protected by a rod in September of that year. By 1782 over 400 rods protected structures in Philadelphia.

Franklin's own first recommendations for the construction of lightning rods were published in the issue of "Poor Richard's Almanack" for the year 1753. In the 20 years following his proposal for the use of lightning rods, Franklin observed from London in 1772 that in addition to the many installations in America during those 20 years, such rods had been erected in London and in country places on homes, private and public buildings, powder magazines, churches, palaces, and on ships' masts. The first of these was by William Watson in 1762 on his London home.

The installations were not made without resistance to the idea of interfering with the ways of nature or divine will, nor without controversy as to the best method of terminating the top of the rod. Some objected to a pointed tip, preferring a knob, thereby forgetting Franklin's main claim as to the advantage of a pointed tip in silently drawing off and dissipating a lightning charge. Those who objected to points did so for the reason that points would tend to draw lightning to the location being protected, thereby endangering it. In Bologna, the electrical experimenter Giuseppe Verratti erected a lightning rod, but was met by strong antagonism from the local populace. The Pope, Benedict XIV, thereupon wrote a letter advocating the use of lightning rods, but this helped Verratti little, and the project was abandoned.

In 1782, the magazine of Fort Malaga in Sumatra, containing 400 barrels of gunpowder, was struck by lightning and exploded. Lightning rods which had earlier been installed there, had been ordered removed by the Council of the East India Company, on advice given them that lightning rods were not a protection but a danger. De Saussure investigated the reason for the immunity enjoyed by the ancient cathedral at Geneva, a stone structure with central tower built of wood, which, for three centuries before it was fitted with lightning rods, had suffered no lightning damage. He found the wood tower completely covered with tinned iron plate which was connected to ground by several iron structural paths.

A strong supporter of Franklin and popularizer of his theories was Joseph Priestley (1733-1804), possessor of a restless and universal mind. He was a schoolmaster near Leeds when he first experimented with an electrical machine. He became acquainted with Franklin, Watson, Canton, and other electricians and in 1767 he published his first book, an exhaustive work on electricity, in two volumes which he had produced in quite a short time. With help and encouragement from his contemporaries,

Partial text of "Early Electrical Machines," published by the Burndy Library.

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Fig. 1. Martinus van Marum.

he reviewed the current theories of the nature of electricity, suggested lines of further investigation and described the electrical machines and allied apparatus. He detailed his own electrical experiments which had won him membership in the Royal Society the year before. In these and in subsequent experiments, he had noted the strength of the air currents accompanying an electrical discharge from the points of charged conductors, enough to blow out a candle. He included carbon, dry ice, and red hot glass among conductors, and he attempted to prove by experiment that electrical attraction and repulsion obeyed the inverse square law. He repeated Franklin's experiment of observing no effect on a pair of pith balls hung within a charged metal container. In his book, he explained the rings, later known as "Priestley's rings," that were formed by an electrical discharge on a metallic surface. He proposed an explanation for the oscillatory character of the discharge from a Leyden jar. Priestley, in his book, considered Franklin's lightning-electricity similitude "the greatest, perhaps, that has been made in the whole compass of philosophy since the time of Sir Isaac Newton."

In 1756, Franklin was elected a Fellow of the Royal Society in recognition of his electrical contributions, and in England and France, as in the United States, he became one of the most popular men of his time. It was the French statesman Turgot who lauded Franklin by the phrase to be forever related to him: "Eripuit coelo fulmen, sceptrumque tirannis" (He snatched lightning from the sky and the scepter from the tyrant).

Always eager to turn a new phenomenon of nature to the cure of the sick, many rheumatics and paralytics flocked to Franklin for electrical treatment. He gave them all the same dosage—the shock of two six-gallon jars through the affected limb, three times a day—noted an improvement during the first few days (which he ascribed to the activity of the travel and treatment) and a relapse after five days.

We read with pleasure the words sent by Franklin, among the foremost of those who lit the electric torch that has illuminated the world in the last two centuries, to his friend Collinson on April 29, 1749: "Chagrined a little that we have been hitherto able to produce nothing in this way of use to mankind; and the hot weather coming on, when electrical experiments are not so agreeable, it is proposed to put an end to them for this season, somewhat humorously, in a party of pleasure, on the banks of the Skuylkil. Spirits, at the same time, are to be fired by a spark sent from side to side through the river, without any other conductor than the water; an experiment which we some time since performed, to the amazement of many. A turkey is to be killed for our dinner by the 'electrical shock,' and roasted by the 'electrical jack,' before a fire kindled by the 'electrified bottle:' when the healths of all the famous electricians in England, Holland, France, and Germany are to be drank in 'electrified bumpers,' under the discharge of guns from the 'electrical battery'." The electric jack mentioned by Franklin was a wooden disc pivoted horizontally, having insulated brass thimbles around its edge which successively touched the terminals of a charged Leyden jar, and being repelled, caused the disc to turn. A fowl placed on the vertical shaft of the disc would thus be properly roasted.

THE VAN MARUM MACHINE

THE ELECTRICAL MACHINE which is best known for its impressive size, history, and magnificent workmanship is the Van Marum machine, finished in April 1784 for the Teyler Museum in Haarlem, Holland. In a paper on the Franklin theory written by Dr. Martinus van Marum (1750-1837), he stated that he had this machine built "for the purpose of observing some phenomena on a large scale by means of the electrical non-equilibrium, and thereby the means necessary to discover and investigate their nature." This machine, having the largest glass disc plates ever used, was constructed by the English instrument maker John Cuthbertson working in Amsterdam. Dr. van Marum was the director, librarian, and chief experimenter of the Teyler Museum which he served for 60 years. The museum had been established from funds left by the Haarlem merchant, Peter Teyler van der Hulst, upon his death in 1778. Born in Delft and a graduate in medicine and botany in Groningen in 1773, Van Marum practiced in Haarlem but turned to general science four years later.

The rotating elements of the huge machine (Fig. 2) consist of two glass discs, each 65 inches in diameter, mounted on a single, yard-long axle and spaced 7½ inches apart. They are rotated by compound cranks with positions for two operators (for long experiments, four operators), working simultaneously. Crank and axle are connected through a universal joint. The machine and experiments made with it were well described in a two-volume book written by Van Marum and issued in French with a parallel translation in Dutch. The difficulty of making such large plates was multiplied by the need to mount them on equally large glass, and therefore

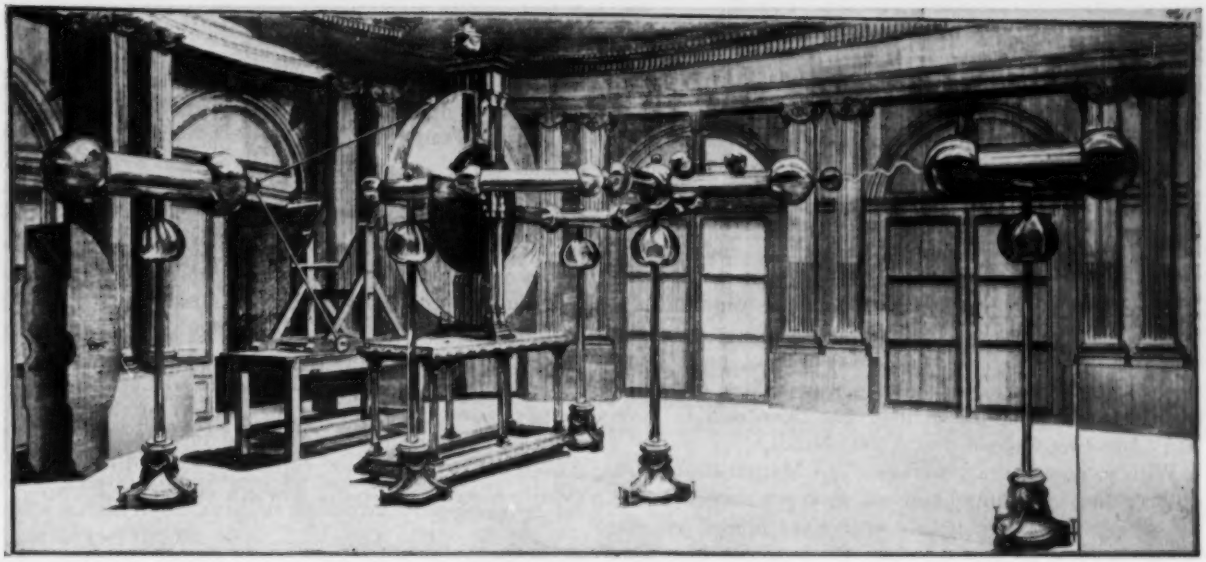


Fig. 2. The Van Marum electrical machine—1784.

fragile, columns serving as insulators for the apparatus. In addition to the eight rubbing pads of waxed taffeta, the machine had collecting metal combs which came to 1½ inches from the inner glass disc surfaces. The receiving standard, shown on the top of the standard at the right in Fig. 2, terminated in two spheres one foot in diameter.

Auxiliary apparatus to serve the machine included a group of seven cylindrical conductors of brightly polished brass, having spherical ends; of these, five rested on glass columns set on wooden pedestals. After many trials, the most effective amalgam for treating the rubbing pads was determined to consist of two parts mercury, one part tin, one part zinc, and one-quarter part, by weight, of mosaic gold. In 1789, Cuthbertson completed a battery of 25 giant Leyden jars each 50 cm (20 inches) high. All the inner leads were connected through brass rods to a large raised central sphere and this was topped by a Henley quadrant electrometer. There was an additional battery consisting of nine units of 15 jars each, forming an assembly of 135 jars, connected in multiple and providing a condenser surface of 103 square feet. Four batteries of Leyden jars were available to Van Marum at the Teyler Museum.

With this equipment, Van Marum drew sparks two feet long and affected an electrometer placed 40 feet from the machine. He conducted many tests in the fusion of metal wires, all of an equal length and a diameter of 1/32 inch and observed the effect of the battery discharge on different metals and alloys. These experiments led him to conclude that copper was the best material, and lead the poorest, for use as a material for lightning conductors. Based on his experiments, he recommended that the use of iron or brass chains (then most commonly used) for lightning conductors on ships should be replaced by copper rod, or copper chain with few links and a weight at the chain's end to force good contact between the links.

Up to that time, the largest machine that had been constructed was that of Edward Nairne (1726-1806), of London, who had assembled a glass cylinder 18 inches in diameter to a crank and frame. This drew the longest sparks that had yet been drawn from any electrical machine. Nairne had also been able to melt iron wire of a diameter of 1/151 inch and of a length of three feet nine inches with the use of 50 square feet of condenser surface, the longest such wire yet melted. Van Marum repeated the experiment with his great machine and was able to melt 15 feet of such wire.

To study the effects of discharges of the machine on magnetic bodies, Van Marum invited Jan H. van Swinden, professor of physics at the Athenaeum at Amsterdam, who, in 1776, had already made such studies but whose equipment was too limited in strength. Together they subjected magnetic iron and steel bars of several dimensions, compass needles, watchsprings and loadstones to electric discharge. Some were unmagnetized, some partially magnetized and others were strongly magnetized. Compass needles were permitted to point in their normal positions before the discharge was made through them, others were placed in a reverse position, still others were pointed vertically. All showed the magnetic influence of an electric discharge through them, even to the reversing of the magnetic poles of a magnet.

When the experimenters placed some iron and steel bars in a position perpendicular to the line of electric discharge, they were surprised to find the resulting magnetic strength stronger than when the bars were placed in the lineal direction of the discharge, a phenomenon already noted by Beccaria. This result was so unexpected and difficult to explain that they repeated it many times and always attained the same results. The phenomenon therefore remained as stated in the report, but without explanation. Although this occurred 35 years before Oersted's discovery in 1820 (the presence of a magnetic

field about a wire carrying a voltaic current), it becomes even more surprising that this interrelation should have remained unobserved and unexplained by the many investigators during this long and active period.

To test his theory that earthquakes might be of electrical origin, Van Marum arranged two wooden planks with a thin layer of water between them. On the upper plank he represented buildings by means of wooden blocks. He then discharged his machine and battery through the layer of water and watched the violent upheaval that caused the blocks to tumble. With this apparatus, he was also able to melt gold leaf and a length of iron wire 1/40th inch in diameter and six inches long. A discharge through a cylinder of wood three inches in diameter and three inches long was calculated to have had a bursting force of over 5,500 pounds.

With so powerful a generator, Van Marum could also observe the branchings and ramifications between the massive electrodes, and he tried to relate the direction of the branchings to whether the electrode was positive or negative, and thereby to confirm Franklin's one-fluid theory. Van Marum prepared a sketch of such a spark and visited Franklin in Passy with it. Although the visit was on the eve of his return to America, Franklin carefully examined Van Marum's sketch, posed some questions and then stated, "This then proves my theory of a simple electric fluid, and it is now high time to reject the theory of two sorts of fluids." Volta, to whom Van Marum had sent reports of his experiments, was equally strong in recognizing the "proof," the affirmation of the unitary theory.

(The final installment in this series will appear in the October issue. It will carry an account of the development of electrical instruments and the contributions of Alessandro Volta whose voltaic pile or direct-current electric battery initiated a new era in electric science.)

Recommended Grounding Practices for Single Polarity D-C Structures

AIEE CONVERSION SUBSTATION SUBCOMMITTEE

General principles and recommendations for grounding apparatus and supporting structures in d-c substations where one polarity is grounded are discussed in this report. Observing these suggestions should result in maximum safety to personnel and equipment.

SUBSTATION GROUNDING PRACTICES on electrical circuits are well standardized for the different a-c and d-c services. However, grounding practices for other material in a substation such as switchboards, supporting structures, transformer cases, and machine frames do not seem to be as well publicized. It is the purpose of this report to discuss the general principles involved and recommended guides for grounding practices.

Grounding practice of structure for a-c and d-c services are necessarily quite different. This is particularly true if one polarity of the d-c circuit is grounded. As one operator stated: "We would like to house the two d-c polarities in separate buildings if we could." This attitude may be more readily appreciated when the differences in interrupting a-c and d-c arcs are considered. In interrupting a-c, the voltage and current waves naturally go through zero at the rate of twice per cycle. To sustain the a-c arc, the path must break down again as the voltage increases from zero. The current in the d-c arc does not go through zero naturally but must be forced to zero by building up an arc voltage to a value higher than that of the service voltage. The arc energies are, therefore, much higher for interrupting d-c than for a-c. This results in the production of many, many times the volume of ionized gas. Again, for a given electrical circuit of the same voltage, the fault current is usually lower for a-c than for d-c. The temperature effects from high current arcs are more damaging than those resulting from low current arcs. Because the ionized gases are highly conductive, special attention must be paid to de-ionizing the gas path quickly and to guiding the gas away from conductors of the opposite polarity into areas where they can do no harm. This is particularly true of cases where breakers are metal-enclosed and used on circuits where one polarity is grounded. Handling of the gases from breaker interruptions is relatively easy as designs are made on the basis that such faults are expected. Accidents as described in the appendix occasionally occur

Essentially full text of paper 57-719, "Recommended Grounding Practices for Single Polarity Direct Current Structures," recommended by the AIEE Committee on Substations and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

M. E. Reagan Westinghouse Electric Corp., East Pittsburgh, Pa., is chairman of the AIEE Conversion Substation Subcommittee.

inside the cubicle but apart from the breaker. No advance notice is given as to the nature of the fault. Many types of accidents may occur which can cause the ionization to start. Some of them are mentioned in the case histories detailed in the Appendix.

Grounding one polarity of d-c circuits is standard practice on railway and mining* systems and sometimes used on the heavy type industrial installations such as steel mills. Even electrochemical potlines are sometimes grounded at their mid-point, and seem always to have enough leakage to be troublesome. Services such as the 250-volt, low capacity, d-c light industrial systems serving general purpose loads, cranes, lighting, battery charging, and similar services have no intentional ground connections and use a breaker pole in each polarity. Even these systems may use some form of ground detection so that an accidental ground may be located and removed before a second one may occur on the opposite polarity and cause a short circuit.

In order to minimize the danger to personnel and equipment, all railway control switchboards built up to and through the 1920's were mounted on wood sills and had insulators in the wall supports. The panels were made of marble, slate, or ebony asbestos and mounted with iron pipe or angle iron supports. A publication of that era stated: "All d-c switchboards for circuits having one side connected directly to ground, for example, a railway switchboard, should have cases, frames, and associated structures insulated from ground. In general, they should be grounded for other d-c switchboards. In mixed switchboards, for example, one having both a-c and railway panels, a literal interpretation of the safety code requires that the a-c panel frames and associated structures be grounded and the d-c panel frames and associated structures be insulated." Although there was no mention of voltage, it became common practice to apply these rules to 300 volts d-c and above.

In the early 1930's, steel structures and steel switchboards gradually replaced the insulating panels. As a result, the circuit breakers were separately mounted, and were either metal-enclosed or of the modern drawout type. The metal-enclosed and drawout types made careful gas-handling imperative as one polarity (the circuit interrupter) would be entirely surrounded by the other polarity (the grounded framework) with its constant invitation to short-circuit. These changes have brought forward suggestions that the structures be insulated on grounded electrical d-c circuits as low as 250 volts. This would extend the practice to all of the coal-mining* and a portion of the heavy duty steel mill services. This is a reasonable conclusion also as all of the elements are present to cause trouble and increase the hazard to personnel and equipment. Faults inside of such structures are of an accidental nature and, therefore, cannot be predicted. The various types of accidental faults can perhaps be best understood by recalling a few of the experiences in the past on each of the four classes of services. These instances are typical of the types of failures encountered and are listed in the Appendix.

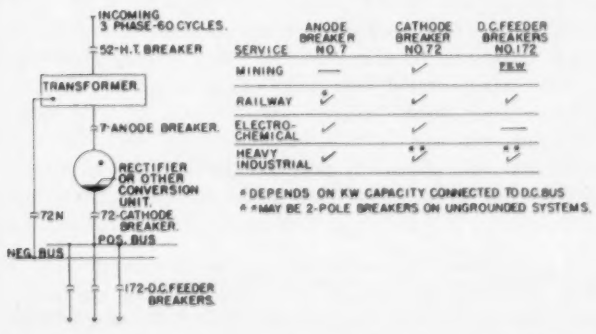


Fig. 1. Conversion substation maximum equipment layout with table of apparatus by industries.

BASIC RULES

IN APPLYING the recommended grounding scheme to d-c services, several basic rules suggest themselves:

1. Minimize the exposure area of nearby points of opposite polarity as much as possible.
2. Co-ordinate the clearance distance between points of opposite polarities with the value of fault current so that the arc will not be self-sustaining.
3. Use rubber mats to protect the operating and maintenance personnel. This exposure to danger can occur only during the few cycles that separate the application of the fault and opening of the isolating circuit breakers. There is no possibility of building up static charges on the structures as they are grounded at all times through the operating coil of relay No. 64.
4. Minimize the exposure particularly on the load side of the interrupter in order to reduce the probability of a fault being sustained by voltage from another substation.
5. Review the design of the distribution system to assure that a fault at the most remote point of a feeder (with allowances for arc-drops and contact resistances) will operate the overcurrent tripping element of the breaker.
6. Where it is necessary to use closer than recommended clearance dimensions, special precautions must be taken to guide the ionized gases from circuit interruption to areas where they cannot contact points of opposite polarity.
7. Keep sources of any other a-c or d-c potentials out of steel enclosures as much as possible.
8. When the potential leads of foregoing point 7 must be located within the cubicle, insulating covers over the terminals should be used.

Fig. 1 shows a single line diagram of a rectifier unit with all of the necessary switching devices, some of which are not used in all applications. The table in Fig. 1 shows the usual breaker application in the various industries. With the exception of the a-c breaker No. 52, all other breakers and their structures must be considered when grounding practices are being determined. The rectifier frame or housing, the auxiliary control cabinet, and heat exchanger must also be examined for maximum safety. Grounding practices on rotating machine frames must

necessarily vary with the type of machine. The frame of a synchronous converter may be insulated by setting on a sufficient thickness of dry concrete and then grounding in the recommended manner through a relatively high resistance ground protective relay No. 64. In the case of motor-generator sets with a common frame, the a-c voltage of the motor may determine that high resistance grounding of the frame is undesirable. Ground protective relays, operating from an impulse coil in the machine ground lead, have been successfully applied.

Fig. 2 is a schematic sketch showing the connection of the ground relay No. 64 with a supervision circuit. The latter is felt to be necessary inasmuch as the protective circuit may be made inoperative by either an open circuit or by having its coil short circuited. The alarm sounds in either case and also in case of loss of its a-c supply. The supervision circuit also means that there is a small d-c voltage on the structure at all times. This voltage should be low enough to prevent any hazardous shock to personnel. Voltages of the order of 35-40 volts are in common use today. The operation of relay No. 64, in addition to initiating alarms, must initiate tripping of all circuit breakers necessary to isolate the fault. Relay No. 64X (the supervision relay) should, as well as relay No. 64, operate a local alarm and, when remote indication is used, should also operate remote visible and audible alarms. The remote visible indication and the local alarm should be maintained until the initiating fault has been corrected. The maintained local alarm and the use of the insulating mats should be covered by mandatory rules. Remote alarms are strongly recommended. All alarms must be investigated promptly and the causes corrected. In unattended stations with supervisory control, the supervising relay should be used to notify the power dispatcher that the ground protective system is inoperative.

Rectified a-c is used for the supervision energy supply. The insulating transformer steps the service voltage down to obtain from 35 to 40 volts d-c. The ground connections are made in order that the actual circuits to ground be supervised. The supervision relay No. 64X is normally energized and held in the operated position. It will de-energize if (a) the a-c service is lost, (b) an a-c fuse operates, (c) an open circuit develops in the d-c supervision circuit, or (d) if a short circuit around its operating coil should develop. Relay No. 64 operates only when the power circuit accidentally connects to the grounding bus.

Fig. 3 gives approximate dimensions below which d-c arcs of low amperages will not extinguish at several voltages. The information from which these curves were drawn is based on a series of laboratory tests. They contain a fair factor of safety as their successful use over a long period of time would imply. The use of enough clearance on the load side terminals of circuit breakers is especially recommended inasmuch as the small arc may be supported by voltage from some other substation. These curves show that, for 10 amperes fault current, the clearance dimensions between positive and negative should exceed 6 inches for 300 volts, 11 inches for 500 volts, and 15 inches for 700 volts. They also show that the clearances may be reduced as the ground relay coil resistance is increased to limit the fault current to a value less than 10 amperes.

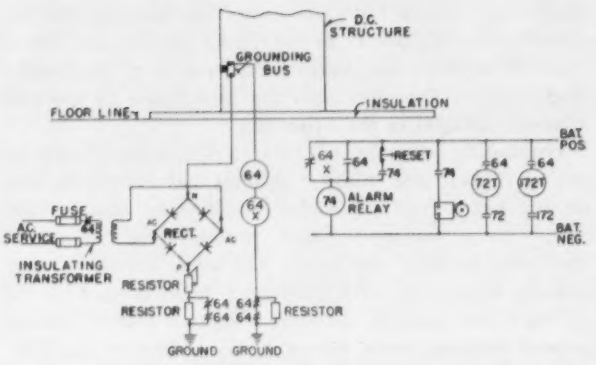


Fig. 2. Schematic diagram of connections for ground protective relay No. 64 with supervision relay No. 64X.

HIGH RESISTANCE GROUND SAFER

ONCE IN A WHILE, the argument is advanced that a cubicle which is "solidly" grounded must be safer to personnel than one that is grounded through a high resistance." This is true for high voltage a-c circuits as explained in AIEE Report No. 953, October 1956. Many years of operating experience have shown the opposite to be true for single-polarity d-c circuits. High currents have injured many persons on d-c although high voltage is relatively safe. Physical danger to personnel may be caused by: (a) high enough voltage to cramp the muscles, making it impossible for the victim to free himself; (b) blindness caused by heavy-current flash; (c) clothing ignition caused by a heavy-current flash; (d) consequential damage such as broken bones and bruises caused by sudden release of energy or muscle reaction which causes the victim to strike other objects; and (e) flying objects such as glass resulting from an electrical "explosion" within electrical devices (relays and instruments).

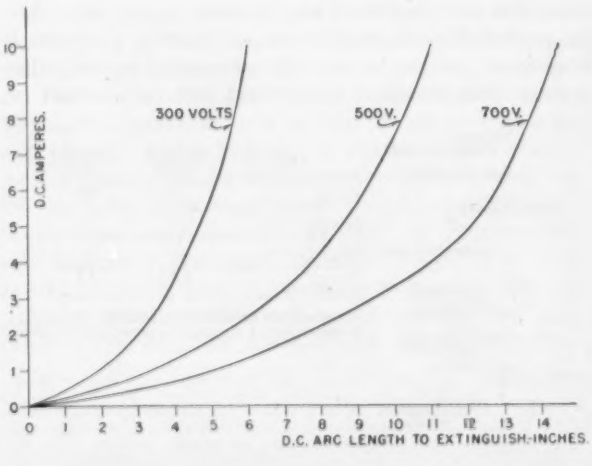


Fig. 3. Guide for clearance distances for apparatus which may remain energized after relay No. 64 has operated.

When a fault occurs, the cubicle with a grounding resistance will be raised to the full system voltage above ground for the few cycles that it takes to trip the isolating circuit breakers. The man who might be connecting the cubicle to a grounded conduit, for example, would be subject to injury as described in foregoing points (a) and (d), but not as stated in (b), (c), and (e). However, the chances of his being connected to the two polarities are small, particularly if the use of rubber mats is followed. In case the cubicle is "solidly" grounded, the man would be subjected to all five of the hypothetical dangers, although (a) would be a much lower voltage. The voltage of (a) under this condition would be the voltage drop in the ground lead at the reduced system voltage under short-circuit current conditions. As a result, records show many severe injuries to men caused by faults in the "solidly" grounded cubicles and no injuries from those installations where resistance grounding curbs the current flow to a low value.

Although there are very few installations of this type made in outdoor housings, it is felt that conditions can vary in such great degrees that the application of the grounding rules must be decided in the light of local conditions. In general, it is felt that outdoor housings should be as "solidly" grounded as possible. This would indicate a strong reason for locating all d-c gear indoors.

SUMMARY

THE FOLLOWING CONCLUSIONS are strongly recommended:

1. That metallic structures of d-c power and control circuits be (1) insulated from ground and (2) grounded through a relatively high resistance ground relay No. 64 when (a) the rated d-c voltage is 275* and above (optional on lower d-c voltages) and (b) when one polarity of the d-c circuit is grounded.
2. That some of the normally ungrounded (not purposely grounded) d-c systems be considered as grounded when local operating conditions make it difficult to keep the circuitry free from grounds. The degree of these grounds (resistance value) must be such as to limit fault currents to a value considered safe to personnel and equipment.
3. That the ground protective relay circuit be continuously supervised by a relay No. 64X.
4. That the operation of relay No. 64 initiate tripping of all circuit breakers necessary to isolate the fault. That the operation of relay No. 64X as well as that of relay No. 64 initiate a local alarm, and, when remote indication is used, also initiate remote visible and audible alarms. That the remote visible alarm and the local alarm be maintained until the initiating fault has been corrected. That the maintained local alarm and the use of insulating mats be covered by mandatory rules.

Recommendations for grounding metal structures surrounding single-polarity, d-c circuits are different than those for surrounding ungrounded d-c or a-c systems. For more than 50 years, it has been common practice to insulate the surrounding structures of d-c apparatus (300 volts and above) where one polarity is grounded and switching is done only on the opposite polarity. When the electrical system is ungrounded, two pole circuit breakers are used and the surrounding structures are grounded as explained in Chapter II of AIEE Report No. 953 October 1956. Case histories show that danger to personnel results from high currents rather than high voltage.

Appendix

RAILWAY SERVICE CASE HISTORIES

THIS SERVICE covers 600-750, 1,200-1,500 and 3,000-3,300 volt d-c railway operations. The 600-750 volt class covers the city traction and many of the interurban systems. Although these services were very numerous in the past, many have since ceased to exist. There are several semi-heavy traction systems in service using the 1,200-1,500 volt equipment. The 3,000-volt applications are limited to the heavy traction duty of which there are several in this country and many in foreign countries. As previously mentioned, the application rules of insulating the surrounding structures have been recognized for many years but occasionally the rules are either forgotten or ignored.

Case RA: Three rectifiers on 650-volt city traction service had drawout, metal enclosed cathode breakers. The cells were solidly grounded to the building steel in the basement of a downtown office building. The operator was in the process of putting one of the rectifiers in service. Standing on insulated floor covering, he was closing the cathode breaker and looking at the d-c ammeter located directly in front of him. The slight mechanical jar accompanying the closing of the breaker dislodged a sliver of steel that someone had accidentally left on top of the cubicle. In falling, the sliver connected one of the d-c ammeter shunt leads to the grounded steel cubicle, causing a direct short circuit. The ionized gases from the vaporized sliver connected the main bus to the cubicle with several thousand amperes flowing which destroyed not only its own housing but the adjacent ones. But, of a more serious nature, the ammeter exploded in the operator's face. Fortunately, his eye-glasses saved him from serious injury. Some of the tie-feeders connecting this bus to other d-c substations did not draw enough current to trip the breakers and the fire could have caused great damage and panic in the office building, had not the partially blinded operator had the presence of mind to run the length of the feeder board and trip each breaker by hand. The units affected were out of operation for several weeks. All of this damage would have been avoided if the original recommendations of insulating the cells and grounding them through a relatively high resistance ground protective relay (No. 64) had been followed. The units would have been taken out of service with no damage to equipment or personnel. The resistance of the relay (No. 64) coil would have limited the fault current to a very low amperage and tripped all of the necessary breakers to completely isolate the fault. The ammeter would not have been harmed. The service would have

been interrupted for a few minutes only when all apparatus could be restored to service.

Case RB: On a heavy-duty d-c feeder of a substation serving a heavy third-rail traction system, a maintenance man was checking the tightness of studs on terminal blocks and other connections on the rear while the panel equipment was in service. His screw driver slipped and caused a short-circuit. The hot, ionized gases quickly connected the 650-volt power conductors to the solidly grounded angle-iron framework. The large flash blinded the man and set fire to his clothing. Only fast work on the part of another employee saved his life. The equipment and connections on the rear of the panel were badly damaged and the feeder could not be returned to service for several weeks. The damage to both the men and the equipment would have been avoided had the framework been isolated from ground.

Case RC: A feeder panel in a metropolitan traction substation was installed in such a manner that some grounded conduit was run directly over and too close to the top of the d-c breaker arc-chute. In opening a particularly heavy short-circuit, ionized gases connected from the breaker contacts to the grounded conduit resulting in great damage to both. In addition, the arc flowed to the rear of the panel and traveled along the positive d-c bus, damaging several other feeders.

Case RD: In a 3,000-volt heavy traction d-c substation, pedestal mounted d-c breakers were used. The supporting structures of the breakers were made of angle-iron which was, unfortunately, solidly grounded. The control panel was mounted on the side of the breaker frame. The conduit for the control wiring came out of the floor and pointed toward the rear of the control panel, and more or less at the breaker. During a period of some very hot, humid weather, a short circuit developed inside the conduit buried in the concrete floor. The hot gases shot from the end of the conduit like a gun aimed at the breaker and control. The breaker insulation was bridged resulting in a complete burn-up of the breaker and control. This loss of equipment and service could have been completely avoided by insulating the breaker framework from ground.

Case RE: In a 600-volt heavy traction substation, the d-c switchgear was metal enclosed. An instantaneous, sensitive, low resistance type ground relay and d-c lightning arresters were included. The purchaser did not connect either the ground relay or the lightning arresters, although both were on hand when the equipment was put into service. The enclosure was grounded solidly.

During an electrical storm, lightning struck the d-c distribution system near the station, causing a flashover inside the gear.

Considerable damage was done by the power current that followed the flashover. The switchgear was repaired, but the user again neglected to connect either the arresters or the ground relay which were still on hand in the substation. During another electrical storm, the switchgear was again damaged severely when the station was struck by lightning.

After the switchgear was repaired the second time, the user installed the arresters and the ground relay. During a subsequent electrical storm, the station was struck again. The ground relay tripped all breakers and cleared the station with only minor damage at the point where the flashover occurred. Although the low resistance ground relay actually limited the damage, there would have been no damage at all if a high resistance type relay had been used.

Case RF: The rectifier auxiliary cabinet usually houses the "firing" circuits and apparatus which is fed by an unfused rectifier positive conductor. Several cases have been reported when faults within the cabinet result in complete destruction caused by solidly grounding the cabinet. Present recommendations call for the inclusion of this cabinet in the group which is insulated from ground and grounded through the operating coil of relay No. 64.

MINING SERVICE CASE HISTORIES

THIS SERVICE* COVERS rather small, usually 300- and 500-kw, conversion units of both 275- and 550-volt classes. Here again, all of the dangerous elements are present for causing damage to personnel and equipment. It is likewise recommended that the surrounding structures be insulated from ground and then be connected to ground by a relatively high resistance ground relay. This should be recommended for both the stationary and portable types of equipment.

Case MA: A portable 275-volt rectifier substation with a drawout-type cathode breaker was in operation in an "entry" room within a coal mine. Some foreign object or animal such as a mouse or snake short circuited the insulator that separated the live and dead parts of the breaker, resulting in the destruction of the breaker. This could have been avoided if the car had been insulated from ground and then grounded through a relatively high resistance ground protective relay.

Case MB: On a portable mining unit, the slow accumulation of potash dust with moisture short circuited an insulator which produced a d-c short circuit on 275-volt service. Because it was on the load side of the breaker and the current flow was not enough to trip the remote breaker, the d-c breaker was destroyed. Again this could have been avoided if the rules had been followed.

HEAVY INDUSTRIAL SERVICE CASE HISTORIES

THE MAJORITY of this class of equipment is ungrounded and use 2-pole breakers—a pole in each polarity, Ground detectors are employed and, when such grounds are detected, they are quickly located and eliminated from the system before a ground can develop on the opposite polarity by the probability law. Where single-pole breakers are employed on a grounded system, each ground appearing on the ungrounded conductor results in a short circuit. There are some systems which employ only single-pole breakers in one polarity on ungrounded systems. In this case automatic ground detection with alarms and immediate investigation is indicated.

Case IA: In a rectifier station for 250-volt d-c ungrounded heavy duty industrial service, the switchgear enclosure was solidly grounded. A short-circuit between opposite polarities and between both polarities and ground caused the feeder breaker to trip. It so happened that an electrician was standing in front of the breaker unit at the time. He immediately reclosed the breaker by its control switch. The breaker, reclosing on a solid short-circuit and ground, went through a trip-free operation, but, because of the accumulation of hot gases from the immediately preceding high current interruption, there was a flashover from a portion of the breaker frame to the grounded metal enclosure which burned a hole about four inches in diameter into the side sheet. The accumulated pressure blew hot gases into the adjacent unit through the hole, permitting the current to arc to the breaker in that unit (which at that time was of the opposite polarity because the feeder was still short-circuited). Damage was limited to the hole in the side sheet and some minor burning of the breaker frames. If the metal enclosure had been grounded through a high resistance ground relay, no damage would have been done.

ELECTROCHEMICAL SERVICE CASE HISTORIES

IN POTLINE SERVICE for reduction of aluminum and magnesium or producing such products as chlorine etc., large d-c energies were used. Gas-driven engines with d-c generators are paralleled when the fuel supply is adequate and the least expensive. Rectifiers are used in the greater percentage of installations. The d-c voltages used go as high as 1,000 volts, although the vast majority use voltages of 600 to 800 volts. Depending on the design of the "pots," the currents employed have reached a peak of more than 125,000 amperes. However, the potline design calls for many "pots" being connected in series and covering several acres of territory. This fact, with other conditions, makes for frequent accidental grounds on one of the two polarities. There is a leakage all along the length of the average potline which varies from 50 to 300 amperes. Constant supervision discloses any low resistance grounds which are eliminated as quickly as possible. Additional hazards are present because the potline cells can feed energy into faults after the power feed circuits have been interrupted.

Case EA: Before the facts of potline leakages were realized, such loads were considered as ungrounded. As a result, the structures surrounding the d-c structures and interrupters were solidly grounded. In one large installation, two rectifier cathode breakers were badly damaged when ionized gas paths became established between the breakers and the grounded cells. Ultimate tests showed that a low resistance ground path existed all along the cell line where concrete reinforcement rods had been contacting the pots because of a misunderstanding on the part of the installation contractor. Test grounding of the potline positive conductor showed currents in excess of 10,000 amperes. To all intents and purposes, the line was "solidly grounded." Inasmuch as it is felt that even 50 amperes leakage is quite dangerous, present recommendations call for treating electrochemical potlines as though their circuits were grounded.

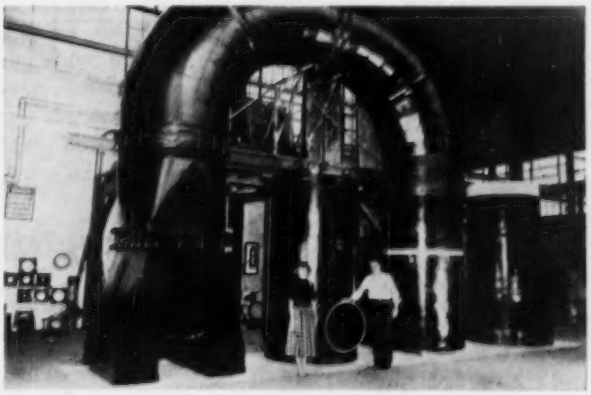
All of the cases cited thus far have been examples of damage caused by *not* following these guides. Many case histories could also be compiled to show the huge benefits that have been achieved by observing the recommended grounding guides. Where the installations have been properly made, an accidental ground operates the ground protective relay which trips those breakers necessary to isolate the fault. No burning of equipment or harm to personnel results and the equipment may be restored to normal service with a minimum of delay. This type of fault is limited to very small currents. It is unfortunate that all electrical faults cannot be limited in a similar manner.

* The grounding of structures on coal mining equipments must be decided finally in view of local conditions. The committee feels that this recommended practice is right when the substation equipment is installed in a clean, dry room. Grounding conditions in coal mines remain a controversial subject.

Plastic Fume Duct System

This fume duct system designed to handle wet sulphur dioxide and H_2SO_4 fumes resulting from metal finishing operations, is one of the largest fume duct exhaust systems ever produced. It is large enough so that two men could easily crawl through side by side, strong enough to be virtually self-supporting, and resistant enough to chemical corrosion so that it outlasts stainless steel three to one.

This fume duct was installed at a cost said to be well below that of other corrosion resistant materials. Service life expectancy is claimed to be substantially greater than for stainless steel according to an announcement by Haveg Industries, Inc. of Wilmington, Del., manufacturers of the duct.



Closed-Loop Frequency Response of Nonlinear Systems

KATSUHIKO OGATA
ASSOCIATE MEMBER AIEE

WHEN A NONLINEAR feedback control system includes saturation, the output of the system may oscillate with either the input frequency or the $1/n$ order subharmonic of the input frequency, where n is a positive integer greater than 1. When the frequency of the output is $1/n$ times that of the input, the output oscillation is called the $1/n$ order pure subharmonic oscillation. The possibility of the occurrence of pure subharmonic oscillations as the response of a nonlinear feedback control system may be predicted from an accurate closed-loop attenuation–frequency curve for a given input amplitude. That is, if the maximum ratio of the system output amplitude to the system input amplitude is large (about 3 db or more), there is a possibility that the output of the system may oscillate with a subharmonic of the input frequency. However, if the maximum ratio of the output amplitude to the input amplitude is small (about 2 db or less), the possibility of the occurrence of pure subharmonic oscillations is very small, if any. Because of the fact that the wave form of the output of a nonlinear element is often extremely nonsinusoidal and it is difficult, in general, to handle nonlinear differential equations, graphical techniques are usually employed for finding the closed-loop frequency response of nonlinear feedback control systems.

An analytic method for finding the closed loop frequency response of nonlinear feedback control systems has been developed. This method employs the periodic response function defined herein as the Laplace transform of the steady-state wave form of the output of a nonlinear element when the input to that element is periodic. The main difference between the analytic method and the well-known describing-function method is that the former takes the effects of all or most of the higher harmonic components of the nonsinusoidal output of the nonlinear element into account for finding the system output, while the latter takes only the fundamental harmonic component of the nonsinusoidal output of the nonlinear element into consideration. The closed-loop frequency response curves obtained by the analytic method are accurate and may be used for predicting the possibility of the occurrence of subharmonic oscillations.

The analytic frequency-response solutions of the second-order feedback control systems may be shown with (1) saturation nonlinearity, (2) on–off nonlinearity, (3) on–off and dead-zone nonlinearity, and (4) saturation and dead-zone nonlinearity.

Closed-loop attenuation-frequency and phase-frequency characteristics for the systems mentioned may be obtained by merely substituting system constants and input amplitudes into corresponding equations. The present analytic method is also applicable to nonlinear higher-order feedback control systems.

As an example, consider the second-order feedback control system with on–off nonlinearity shown in Fig. 1. The output of the nonlinear element is a square wave. The analytic frequency-response solution for this system may be written as follows:

$$C_p = KM_nT \ln \cosh \frac{\pi}{2T\omega}$$

$$\phi = 180^\circ\left(1 - \frac{T\omega}{\pi} \ln \cosh \frac{\pi}{2T\omega}\right) - \sin^{-1}\frac{KM_nT}{A}\left(\frac{\pi}{2T\omega} - \tanh \frac{\pi}{2T\omega}\right)$$

where

$$0^\circ < \sin^{-1} \frac{KM_nT}{A}\left(\frac{\pi}{2T\omega} - \tanh \frac{\pi}{2T\omega}\right) < 90^\circ$$

C_p = the amplitude of the system output

ϕ = the phase lag of the system output

K = the gain of the linear element

M_n = the maximum output of the nonlinear element

T = the time constant of the linear element

A = the amplitude of the system input

ω = the frequency of the output

Inasmuch as the equations for finding the closed-loop frequency response of feedback control systems with on-off nonlinearities are not considered very complicated, it may be concluded that the method described may be used most advantageously for finding the closed-loop frequency response characteristics of the feedback control systems having on–off nonlinearities or "high degree" saturation nonlinearities.

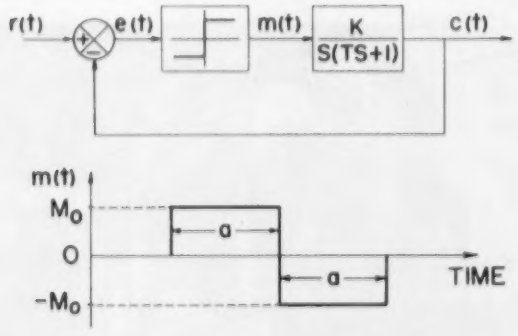


Fig. 1. Block diagram of second-order feedback control system with on–off nonlinearity and output wave form of nonlinear element.

Digest of paper 57-634, "An Analytic Method for Finding the Closed-Loop Frequency Response of Nonlinear Feedback Control Systems," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Applications and Industry*, 1957.

Katsuhiko Ogata is with the University of Minnesota, Minneapolis, Minn.

Economic Aspects of D-C Power Transmission

J. G. HOLM
MEMBER AIEE

CONSIDERATION of the possibilities presented by d-c power transmission is increasing both in this country and aboard. Economic considerations will ultimately determine the choice of the type of current.

A number of overhead a-c power-transmission systems have been designed. Their capital cost includes the cost of the transmission line, with the intermediate substations, and of the terminal substations. A number of d-c power-transmission systems have then been designed, both overhead and underground, transmitting the same blocks of power over the same distances as the a-c systems. Their capital costs include the cost of the transmission line itself and of incomplete terminal substations; i.e., the substations at both ends include the transformers for electronic converters, the synchronous condensers required for operation of inverters, and the harmonic wave filters, but they do not include the rectifiers and inverter themselves. The cost of d-c systems is represented in per cent of the cost of corresponding a-c systems. The per-cent difference in the capital costs of identical systems represents the part of the total cost available for the electronic converters, if the cost of the two systems is to be equal.

The systems studied transmit from 50,000 to 800,000 kw over the distances of 50 to 500 miles. The a-c and d-c systems are designed for as identical security and reliability conditions as are compatible with the characteristics of the two types of systems.[1] The a-c systems have a minimum of two circuits. They are designed for transient stability, with a loss of a circuit or a section of it. The d-c systems are designed for a loss of an entire circuit in case of a fault. They are constant-potential systems, and have either two conductors with midpoint grounded, or are single-conductor ground-return underground systems. The two-conductor underground systems with midpoint grounded are designed for the ratio k of direct to alternating voltage to ground equal to 3.0, 4.5, and 6.0, and the single-conductor ground returns are designed only for $k = 3.0$.

All costs are either for the same year, or reduced to the same year. Fig. 1 gives the cost of a-c overhead systems (curve 1,) d-c overhead systems (curve 2), d-c underground midpoint grounded systems (curve 3, $k = 3.0$; curve 4, $k = 4.5$; curve 5, $k = 6.0$), and d-c underground single-conductor systems (curve 6, $k = 3.0$), for systems transmitting up to 250,000 kw. With the increase in the block of power beyond 250,000 kw and with the increase in the length of the transmission line, the money available for the converters also increases. When the cost of converters is known, it is possible to determine whether d-c transmission is economical and, if so, to what extent.

The underground cable is the logical means for transmitting d-c power. However, with present costs of cable, the overhead transmission gives greater economies. The cost of the underground systems decreases as k increases.

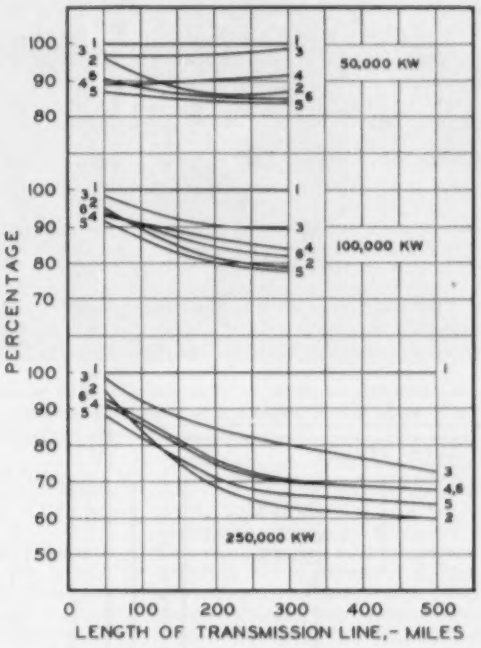


Fig. 1. Capital cost of d-c transmission systems, less the cost of electronic converters, in per cent of the capital cost of a-c overhead systems. Power transmitted: 50,000, 100,000, and 250,000 kw.

The single-conductor ground-return system is cheaper than the 2-conductor midpoint grounded when both systems are designed at same values of k. Should it be possible to lower the cost of power and signal cables and their accessories, the underground systems will become uniformly more economical than the overhead d-c systems. If the design of the d-c systems is made on a different basis than that requiring strict similarity with safety and reliability conditions of the a-c systems, the cost of d-c systems could be further reduced.

When existing overhead a-c lines are converted to d-c operation, the choice of k and the number of circuits per tower has a major effect on the economics of conversion and the cost of power transmitted, greater than in the newly built overhead d-c systems.

REFERENCE

1. Direct-Current Power Transmission, J. G. Holm. AIEE *Transactions*, vol. 72, pt. III, 1953, pp. 1114-20.

Digest of paper 57-630, recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

J. G. Holm is a consulting engineer, New York, N. Y.

INSTITUTE ACTIVITIES

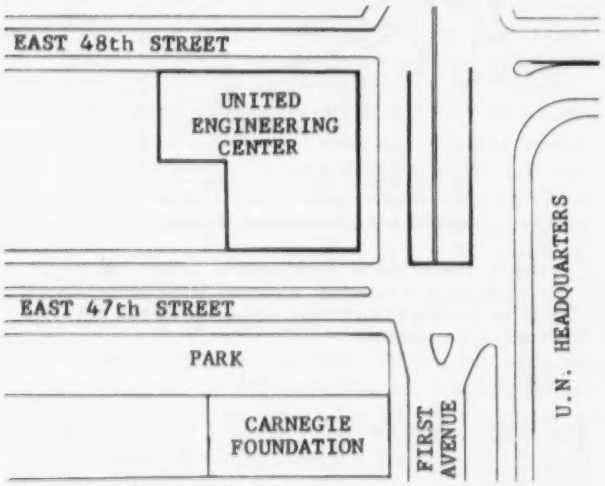
Site for new United Engineering Center Obtained Near United Nations Headquarters

PURCHASE by the United Engineering Trustees, Inc., 29 W. 39th St., of 37,500 square feet of property on the west side of First Ave. between E. 47th and E. 48th Streets at a price of "approximately $2.7 million" was announced on July 31 by W. J. Barrett, president of the Trustees.

The site includes the entire block front on the west side of First Avenue between 47th and 48th St., and extends back from First Ave. for 150 feet on E. 47th St., and for 225 feet on E. 48th St. This section of First Ave. is now the United Nations Plaza.

Title to the principal part of the property was taken by United Engineering Trustees, Inc. on July 31. Included is the portion owned by the Carey Garage Corp. containing a garage with entrance on E. 48th St., and a vacant lot at the corner of First Ave. and E. 47th St. of which P. W. Kuhn was the owner.

Previously acquired from the 849 First Ave. Corp. was a parking lot facing the United Nations Plaza, and a five-story tenement building at 344 E. 48th St. owned by Wallace Carter of New York, N. Y.



A SITE for the new United Engineering Center has been purchased by the United Engineering Trustees, Inc., on First Ave. between E. 47th and E. 48th Streets in New York City.

All negotiations were made through Cross and Brown Co., 270 Madison Ave., New York City.

United Engineering Trustees, Inc., was established in 1904 and is the corporation in which five national engineering societies will now be associated in the development of the new property.

These societies are: the AIEE; the American Society of Civil Engineers; American Institute of Mining, Metallurgical and Petroleum Engineers; American Society of Mechanical Engineers; and the American Institute of Chemical Engineers. More than 175,000 engineers in all parts of the world are members of the five engineering groups.

For 51 years, United Engineering Trustees, Inc., has owned and occupied its 16-story Center on W. 39th St. The structure was built in 1906 by a gift of $1,050,000 from the late Andrew Carnegie ". . . to promote the solidarity of the engineering profession."

Mr. Barrett said that the basic purpose of the United Engineering Trustees, Inc., is to advance the engineering arts and sciences in all their branches. He added that the purchase of the new site is "the first step in plans which the Trustees are formulating to meet a need for the expansion of the Center's activities."

In addition to Mr. Barrett, officers of the United Engineering Trustees, Inc., are: W. F. Thompson of New Haven, Conn., and Andrew Fletcher of New York City, vice presidents; J. L. Kopf of New York City, treasurer, and S. W. Marras of New York City, secretary.

Members and Guests Enjoy Summer General Meeting in Montreal

APPROXIMATELY 2,200 members, their wives, children, and guests attended the Summer General Meeting of the AIEE held June 24-28, 1957, at the Sheraton Mount Royal Hotel, Montreal, Que., Canada. Registration of members exceeded 1,200. Included among the guests were the first prize student winners of the District Student Prize Paper Competitions held during the past administrative year.

Announcement was made at the Annual Meeting held Monday afternoon of the election of W. J. Barrett, transmission maintenance engineer with the New Jersey Bell Telephone Company, as president of the AIEE for the 1957-58 administrative year.

Announcement also was made of the election of five vice-presidents, three directors, and a treasurer. For biographical sketches of the newly elected officers see the April 1957 issue of *Electrical Engineering*.

In his address before the meeting, the outgoing president, M. S. Coover, emphasized that future progress in electrical engineering rests with young engineers who, associated with their elders in the Institute, will be in better position to assimilate today's achievements and continue to develop techniques which will be of universal benefit.

One of Mr. Coover's last official acts was the presentation of the 1956 Lamme Medal to Dr. H. H. Beverage, vice-president, research and development, RCA Communications, Inc., and director of the Radio Research Laboratory of RCA Laboratories. As the 29th Lamme Medalist, Dr. Beverage was cited " . . . for his pioneering and outstanding achievements in the conception and application of principles basic to progress in national and world-wide radio communications."

Four proposed Constitutional amendments were approved by the membership at the meeting.

The Institute also awarded honorary membership to D. A. Quarles, Deputy Secretary of Defense. Mr. Quarles was 1952-53 president of the AIEE.

Inspection Trips

During the meeting there were inspection trips to Hydro-Quebec's Bersimis project located on the north shore of the St. Lawrence River where 150,000-hp, 120,000-kva hydroelectric generating units are being installed, to Hydro-Quebec's 300-kv Bout de L'ile plant which is the Montreal terminal of the Bersimis power development, and a tour of the company's microwave system built to provide private communication facilities between Hydro-Quebec's headquarters in Montreal and two of the world's great power developments—Beauharnois and Bersimis—and the large switch-

ing station at Charlesbourg, near Quebec City. Other inspection trips were made to the Montreal Locomotive Works Ltd., the St. Lawrence Seaway construction area, the Shawinigan Water and Power Company's Sorel Terminal Station located 45 miles downstream from Montreal, and the Quebec Iron and Titanium Corporation's smelter plant. A local visit was also paid to the Canadian Broadcasting Corporation (CBC) Building to view the CBC broadcasting facilities.

Technical Sessions

During the meeting, 274 papers were presented covering more than 50 engineering fields of activity.

Radio Communications Systems. S. Bonneville, of the Bell Telephone Company of Canada, Montreal, Que., reported the growing use of radar for defense as well as aeronautical and meteorological purposes has necessitated serious considerations of possible interference to microwave systems carrying telephone and television signals.

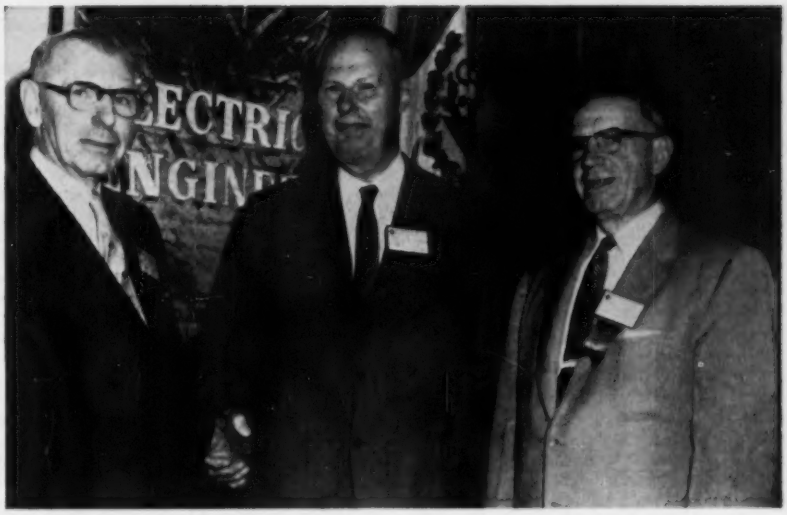
In his paper, "The Canadian Transcontinental Microwave System," the author pointed out that although the band in which radar systems operate is outside that used by telephone common carriers, "side mode and harmonic radiation results in interference in the common carrier bands." The National Research Council in Ottawa and the Bell Telephone Laboratories in the United States, he reported, have carried out extensive tests to determine the extent of the interference problem.

Other papers included "Light-Route Microwave Systems in Canada," by A. J. Dinnin of the Bell Telephone Company of Canada; "A Canadian Point of View on Radio Frequency Spectrum Management," by C. M. Brant of the Department of Transport, Montreal, Que.

Textile Industry. Recent electrical engineering developments in the textile industry were reviewed in a series of eight technical papers and a panel discussion. Papers included "Process Instrumentation from Spinning to Finishing," by J. C. Langlois, Honeywell Controls, Ltd.; "Adjustable Frequency Drives," by A. T. Bacheler and C. G. Hemlick, Westinghouse Electric Corp.; "D-C Adjustable Speed Drives—A Prelude to Automation," by G. Forsberg, Canadian General Electric Co.; "Wire and Cable in the Textile Industry," by G. C. Stinson, Northern Electric Co., Ltd.; and "Electronic Controls as Applied to Process Instrumentation," by A. D. Entwistle, Du Pont of Canada, Ltd. (*Electrical Engineering*, August 1957, pp. 674-76).

Magnetic Amplifiers. W. R. Seegmiller, of the General Electric Company, Schenectady, N. Y., described the development of a high frequency 4,700 cps magnetic servo amplifier used to drive a 400 cps servo motor for military aircraft applications. Mr. Seegmiller's paper, "High Frequency Magnetic Servo Amplifier for Airborne Control Systems," was a partial report on a general development of high frequency magnetic amplifiers for airborne control systems. The reduction of size and weight of equipment is a primary concern in the development of modern military aircraft.

R. J. Distler and C. Sturzenbecker, of the Bell Telephone Laboratories, Inc., described in their paper, "A Magnetic Amplifier Voltage Current Overload Protection Circuit," the advantages of the new protective circuits.



OUTGOING PRESIDENT M. S. Coover *(left)* congratulates Dr. H. H. Beverage *(center)*, winner of the Lamme Medal which was presented during the AIEE Summer General Meeting, as newly elected AIEE President W. J. Barrett *(right)* observes.

Other papers read included "Magnetically Regulated Reference Power Supply," R. A. Raber, General Electric Company; "A Fast-Response, Full-Wave Magnetic Amplifier," G. E. Lynn, Westinghouse Electric Corporation; and "Differential Magnetic Multivibrators," C. H. R. Campling, Queen's University.

Computing Devices. A streamlining operation on the electronic brains that defend the skies over the United States was described by J. J. Gano, of J. J. Gano & Associates, Cambridge, Mass., in his paper "The Elimination of Motor Generator Sets as Transient Buffers for SAGE Computers."

Simplification of the computer setup is accomplished by substituting on-the-spot generation of electric power instead of relying on outside power, the voltage of which must be closely regulated by motor-generators before being fed to the computers. Mr. Gano said that the simpler power supply will result in approximately one computer error in two years, about the same as with the use of motor-generators.

W. J. Canty in his paper, "Experience in Setting Up a SAGE Prototype Computer," reported that extensive tests of a SAGE system prototype show it has a demonstrated reliability of 87% although this type of installation is significantly larger and more complex than any other. The prototype computer, designated *XD-1*, has been installed in an experimental air defense system as a means of gaining experience in the solution of problems peculiar to a system of this magnitude and complexity.

Insulated Conductors. Despite years of research, some early practices of electrical engineers will continue to be useful for years to come, G. E. Bennett, of Dussek Bros. and Co., Ltd., Crayford, Kent, England, predicted in his paper "Paper Cable Saturants, European Preferences and Selection." Mr. Bennett stated: "In spite of the vast amount of research which has been carried out in more recent years on plastics and rubber, which materials are finding increasing use for low and medium voltage cable insulation, the oil impregnated paper dielectrics remain without rival, both from the technical and commercial aspects, for the insulation of high voltage cables."

An extraordinary feat of cable laying in the St. Lawrence River to make Quebec hydroelectric power available to the Gaspé Peninsula was described in a paper, "St. Lawrence River High Voltage Submarine Cable Crossing," by D. M. Farnham, S. Cunha, G. B. Shanklin, and H. D. Short. This engineering accomplishment involved 30 nautical miles of cable at depths up to 300 fathoms in a location with tides of 12 feet and more, strong directional currents and severe weather and sea conditions. The cables in the St. Lawrence, transmitting power at 69,000 volts, weigh 5,572,090 pounds, including 1,350,786 pounds of copper, 2,555,100 pounds of lead and 1,666,204 pounds of aluminum.

Research. H. P. Seelye, consultant for the Edison Electric Institute (EEI) Research Projects Committee told a symposium on research that 763 research projects, many of them of a major nature, are now in progress. His paper, "Edison Electric Institute Survey of Research Projects of the Electric Utility Industry," contained the results of a survey made among the 175 privately owned and operated utilities which are members of EEI.

Wire Communications. A new era in intercontinental telephony has been opened with the recent inauguration of the transatlantic telephone cable, W. E. Bloecker and G. A. Caldwell reported in their paper "The Work of the International Telecommunication Union in the Field of Telephony." Although intercontinental radiotelephone service has been available for 30 years, it was pointed out, the upsurge in traffic which followed the placing in service of the Transatlantic Cable has made it evident that a new era in intercontinental telephony has been born. It is going to be

necessary that the objectives in transmission design, and in the operation of systems of telephony be made compatible to the degree that the advantages offered by these intercontinental circuits are fully utilized in the interest of better communications. This can be done only by worldwide recognition of the importance of good objectives in the design of all national networks which will be practical to interconnect.

C. L. Roach of the Bell Telephone Company of Canada, in his paper "Structural and Electrical Co-ordination in Canada," called for greater co-ordination between Canadian utility organizations because of the increasing widespread use of Canadian power and communication facilities.

Radio and Television Broadcasting. J. E. Hayes in his paper, "The Development of Television in Canada," reported that 65% of all Canadian families now own television receiving sets and in some densely populated areas the percentage is as high as 80%. Although the first television stations went on the air in 1952, the response has been so great that there are now 39 stations, of which eight are CBC owned and 31 privately operated. CBC operates two television network services, one in French, the other in English. At present it has about 2,000 miles of microwave networks in operation and when this service is completed the microwave networks will total 4,000 miles.

Other papers included "The Canadian Broadcasting Corporation's Radio Service in Canada," by N. R. Olding, Canadian Broadcasting Corp.; "Current Practices in TV Lighting and TV Lighting Controls," by H. More, Kliegl Bros., Universal Electric Stage Lighting Co., Inc.; and "A Combining Filter to Allow Simultaneous Transmission from a Single Antenna of Two Complete Television Stations Operating on Different Channels," by G. B. Mac Kimmie, RCA-Victor Co., Ltd.

Hagerstown Educational Television Project. The education potential of television was the theme of four papers presented in a session describing a closed circuit television installation in the school system at Hagerstown, Md. M. H. Kraus of Jerrold Electronics Corporation, Philadelphia, Pa., noted that 6,000 pupils now use the system and eventually all 48 schools in Washington County, Md., which has 18,000 pupils, will be encompassed by the system.

In another paper, "Pioneering in Televised Education," by J. R. Brugger, a member of the Hagerstown Board of Education, it was pointed out that the television system by September 1957 will include addition of 6,000 square feet of operating space, in addition to the 5,000 already in use; a total of 5 live video studios; 6 operating channels, 5 of which are for live use; 21 elementary schools and 2 high schools receiving an aggregate of 27 lessons daily on approximately 510 television sets; participation of approximately 12,000 students in direct and supplemental instruction programs. The text of this paper appears in this issue, pp. 763-67.

Other papers on the subject were: "Establishing and Equipping the Hagerstown Educational Television Project," by L. L. Lewis, Radio Corporation of America; and "Closed-Circuit Network for Educational Television," by W. C. Warman, the Chesapeake & Potomac Telephone Co.

Safety. Problems of radiation control in the operation of a nuclear reactor was the theme of a paper by R. M. Taylor entitled "Medical Aspects of Radiation Hazard Control in a Power Reactor Installation." Dr. Taylor stated that there are two main types of radiation damage—individual or somatic damage and genetic damage. "To reduce genetic damage, it is recommended that the individual exposed to radiation should not receive more than 50 roentgens by the age of 30 and not more than an additional 50 roentgens by the age of 40. The population dose should not exceed 3-10 roentgens per generation.

It was explained that the control of radioactive contamination is exercised in three main ways: control of the contaminated areas, control of ventilation, and control of personnel. In order of frequency, the following problems were encountered at the Chalk River nuclear plant in Canada: (1) contamination of body surface, (2) overexposure to radiation, and (3) internal contamination. In no other industry, he pointed out, has the same effort been made to make the operation 100% safe. "In the light of present discussion and public concern about radiation, I should think it unlikely that there will be any change in this policy in the near future."

Forum of Technical Committee Chairmen Expresses Views on Important AIEE Matters

THE ORGANIZATION and financing of technical conferences, publication of technical papers in advance of presentation, and representation of the technical groups on technical committees as well as means of communication were discussed at the Forum of Technical Committee Chairmen held during the AIEE Summer General Meeting in Montreal, Que., Canada. W. R. Clark, chairman of the Technical Operations Department, presided and drew attention to the responsibility of the technical committees to sponsor joint technical conferences and Institute sponsored conferences. J. Reid, Jr. is chairman of a special committee to handle the conferences.

Technical Conferences

The methods of procedure to initiate special technical conferences and multi-sponsored conferences were outlined by R. S. Gardner, assistant secretary, Technical Committee Activities. The assistant secretary explained that the conferences were practically self-supporting if salaries of his department and travel were not charged as expenses. He stated that the American Society of Mechanical Engineers (ASME) and other societies do not charge headquarters expense and the Institute would be at a disadvantage if these costs were charged to the conferences. For the fiscal year ending April 30, 1957, total income was $21,772 and total expenses $34,262, leaving an excess of expense over income of $12,490. In the course of discussion that ensued, Secretary N. S. Hibshman explained that the Finance and Technical Operations Committees should consider subsidization and to what extent it should be given to these conferences. The forum expressed an opinion that the conferences should be entirely self-supporting by the showing of a large majority of hands; a second showing of hands by technical committee chairmen only confirmed this expression of opinion.

Publication of Papers without Presentation

In introducing this topic, Chairman Clark explained that there were some types of papers which did not lend themselves readily to an oral presentation. Chairman W. S. Hill of the Publications Department stated that the proposal was brought up for application to the Science and Electronics Division only and the Department saw no reason why papers could not be published provided the quality of the papers were maintained by the regular reviewing procedure. He pointed out, however, that it would no longer be possible to publish discussions with the papers. The chairman of the Science and Electronics Division explained the advantages of this method and stated that it would speed up the publication of papers and permit the publication of a technical conference paper after review without delaying for representation. Based on conversation with the AIEE publications editor, A. C. Muir explained that the seven production steps required in an ideal situation—the editing time, setting the type, sending proofs to authors, entering corrections, making up in page form, obtaining revised proofs when necessary, printing, and distribution—would require a minimum of 40 working days. As the frequency was bimonthly and the load not uniform throughout the year, as much time might not be saved as seemed apparent. It was explained by L. F. Hickernell that the Institute once had a publication policy where papers were published in advance of presentation for several years. Without a deadline date for submitting papers, there would not be many contributions.

In conclusion, J. G. Reid, Jr. explained that the proposal had the backing of the Communication and Instrumentation Divisions. By a showing of hands, the forum expressed the view that if a Division desired to have Transactions Papers published without presentation or with presentation at a later time, they should be able to do so and presentation at a conference should be considered as a qualified presentation.

Technical Group Organization

An Ad Hoc Committee, appointed by Past-President M. S. Coover to study the ways and means of initiating technical groups in the Sections and integrating them into the technical committee organization, has accomplished much it was reported by W. R. Clark, a member of the committee. An eight-point program was outlined providing for appointment of the technical

AIEE Future Meetings

Magnetic Amplifiers Conference*
Penn-Sheraton Hotel
Pittsburgh, Pa.
September 4-6, 1957

Petroleum Industry Conference*
Sheraton Hotel
Philadelphia, Pa.
September 9-11, 1957

AIEE-IRE Industrial Electronics Symposium*
Morrison Hotel, Chicago, Ill.
September 24-25, 1957

AIEE-IRE-IIT-NU-U of I National Electronics Conference*
Hotel Sherman, Chicago, Ill.
October 7-9, 1957

Fall General Meeting*
Morrison Hotel, Chicago, Ill.
October 7-11, 1957

Reliability and Quality Control in Electronics Conference*
Silver Spring, Md.
October 10, 1957

AIEE-IRE-ASME Feedback Control Systems Conference*
Chalfonte-Haddon Hall Hotel
Atlantic City, N. J.
October 16-18, 1957

Farm Electrification Conference*
Hotel Nicolett
Minneapolis, Minn.
October 29-31, 1957

EJC-ECPD Engineers General Assembly
Hotel Statler, New York, N. Y.
October 24-25, 1957

Machine Tool Conference*
Hotel Schroeder
Milwaukee, Wis.
November 4-6, 1957

AIEE-IRE-ISA Electrical Techniques in Medicine and Biology Conference*
Harvard University
Boston, Mass.
November 6-8, 1957

Mid-Atlantic Textile Conference
North Carolina State College
Raleigh, N. C.
November 14-15, 1957
(Final date for †TP—closed, ‡CP Syn.—closed, CPMS—Sept. 6)

Magnetism and Magnetic Materials Conference
Park Sheraton Hotel
Washington, D. C.
November 18-21, 1957
(Final date for †TP—closed, ‡CP Syn.—Sept. 3, CPMs—Sept. 13)

AIEE-IRE-ACM Eastern Joint Computer Conference
Park Sheraton and Shoreham Hotels
Washington, D. C.
December 9-13, 1957
(Final date for †TP—closed, ‡CP Syn.—Sept. 24, CPMs—Oct. 4)

AIEE-IRE-ASQC Reliability and Quality Control Conference
Statler Hotel
Washington, D. C.
January 6-8, 1958
(Final date for †TP—Sept. 27, ‡CP Syn.—Oct. 22, CPMs—Nov. 1)

AIEE-IRE Scintilation Counters Conference
Shoreham Hotel
Washington, D. C.
January 27-28, 1958
(Final date for †TP—Oct. 18, ‡CP Syn.—Nov. 12, CPMs—Nov. 22)

Winter General Meeting
Hotel Statler, New York, N. Y.
February 2-7, 1958
(Final date for †TP—Oct. 14, ‡CP Syn.—Nov. 1, CPMs—Nov. 5)

AIEE-IRE-U of P Transistor and Solid State Circuits Conference
Philadelphia, Pa.
February 20-21, 1958
(Final date for †TP—Nov. 8, ‡CP Syn.—Dec. 3, CPMs—Dec. 13)

Textile Conference
Georgia Institute of Technology
Atlanta, Ga.
March 13-14, 1958
(Final date for †TP—Dec. 3, ‡CP Syn.—Dec. 26, CPMs—Jan. 7)

American Power Conference
Sherman Hotel, Chicago, Ill.
March 17-19, 1958
(Final date for †TP—Dec. 6, ‡CP Syn.—Jan. 1, CPMs—Jan. 10)

EJC Nuclear Congress
International Amphitheatre
Chicago, Ill.
March 17-21, 1958
(Final date for †TP—Dec. 6, ‡CP Syn.—Jan. 1, CPMs—Jan. 10)

Pulp and Paper Conference
North Carolina State College
Raleigh, N. C.
March 27-29, 1958
(Final date for †TP—Dec. 20, ‡CP Syn.—Jan. 15, CPMs—Jan. 24)

South West District Meeting
Tulsa, Okla.
March 31-April 2, 1958
(Final date for †TP—Dec. 20, §DP Syn.—Jan. 10, DPMs—Jan. 13)

AIEE-ASME Railroad Conference
Cleveland, Ohio
April 9-10, 1958
(Final date for †TP—Dec. 30, ‡CP Syn.—Jan. 24, CPMs—Feb. 3)

AIEE-IRE-ASME Automatic Techniques Conference
Statler Hotel
Detroit, Mich.
April 14-16, 1958
(Final date for †TP—Jan. 3, ‡CP Syn.—Feb. 25, CPMs—Feb. 7)

Middle Eastern District Meeting
Washington, D. C.
April 28-30, 1958
(Final date for †TP—Jan. 17, §DP Syn.—Feb. 7, DPMs—Feb. 11)

Great Lakes District Meeting
Michigan State University
East Lansing, Mich.
May 5-7, 1958
(Final date for †TP—Jan. 24, §DP Syn.—Feb. 7, DPMs—Feb. 11)

AIEE-IRE-ACM Western Joint Computer Conference
Ambassador Hotel
Los Angeles, Calif.
May 6-8, 1958
(Final date for †TP—Jan. 24, ‡CP Syn.—Feb. 18, CPMs—Feb. 28)

East Central District Meeting
Huntington, W. Va.
May 13-15, 1958
(Final date for †TP—Jan. 31, §DP Syn.—March 7, DPMs—March 11)

AIEE-IRE-RETMA-WCEMA Joint Electronic Components Conference
Los Angeles, Calif.
May 21-23, 1958
(Final date for †TP—Feb. 14, ‡CP Syn.—March 11, CPMs—March 21)

AIEE-ISA-IAS National Telemetering Conference
Baltimore, Md.
May, 1958

Domestic Appliances Conference
Hotel Morrison, Chicago, Ill.
May 27-29, 1958
(Final date for †TP—Feb. 14, ‡CP Syn.—March 11, CPMs—March 21)

Summer General Meeting
Buffalo, N. Y.
June 22-27, 1958
(Final date for †TP—March 14, ‡CP Syn.—April 4, CPMs—April 7)

AIEE-IRE Nonlinear Magnetics and Magnetic Amplifiers Conference
Los Angeles, Calif.
August 6-8, 1958
(Final date for †TP—April 25, ‡CP Syn.—May 20, CPMs—May 30)

Pacific General Meeting
Sacramento, Calif.
August 19-22, 1958
(Final date for †TP—May 9, ‡CP Syn.—June 5, CPMs—June 6)

Fall General Meeting
Pittsburgh, Pa.
October 26-31, 1958
(Final date for †TP—June 27, ‡CP Syn.—Aug. 1, CPMs—Aug. 8)

*Final date for submitting papers—closed
†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
§DP Syn.—District Synopsis
DPMs—District Manuscript

group chairmen and the respective technical committees, the gathering of information to be sent to the technical committees to be integrated in their reports, the correlating of the information at headquarters, and the channels of distribution to the membership such as the bimonthlies and *Electrical Engineering*, with additions to the headquarters' staff to augment the recommendations. As the forum was unfamiliar with most of the recommendations, opinion was expressed that recommendations should be attached to the minutes of the forum and submitted for consideration.

Section Delegates Hear About Progress Toward new United Engineering Center

DURING an all day Section Delegates meeting at the AIEE Summer General Meeting, President-elect W. J. Barrett, also president of United Engineering Trustees, Inc. (UET), reported progress in the steps of acquiring an ideal site for the new United Engineering Center in midtown Manhattan which was highly satisfactory to all concerned. Inasmuch as UET had been given the job of planning and selecting a site, within six weeks after the assignment engineers and architects came up with a recommendation. They had studied whether or not to modernize the existing building, tear it down and rebuild on the present site, or acquire another site and the decision was made that modernization or rebuilding was not practical. Herbert Hoover; Robert Moses, head of City Planning and Commissioner of Parks; and Dr. J. J. Theobold, Deputy Mayor of New York City, rendered invaluable assistance in connection with the matter. Through subsequent developments, the location and further details which were announced later appear on page 806 of this issue. The entire engineering profession is very grateful to President Barrett and the UET for this remarkable accomplishment in the short span of time.

Section Technical Groups

In two group dynamic meetings out of which came a variety of questions from the buzz sessions, the queries most often raised concerned the formation of technical groups in the Sections, the diversity required, ties with the technical committees, and how to initiate and maintain interest. The question was raised by J. C. Strasbourger, chairman of the Administration Department, as to how many Sections had established technical groups and how many had not established such groups. In a canvass, there was no reply from 25% of the Sections. The lack of technical groups might be a reason why the Institute has 2,000 delinquent members, a good many probably feel that they are not being served adequately. The question also was raised as to point of diminishing returns; for example, if a Section should start 20 technical groups and 10 of these have to be dropped.

To provide closer liaison between the Section technical groups and the technical committees, W. R. Clark chairman of the Technical Operations Department, briefly reported that a specially appointed Ad Hoc Committee, comprised of two representatives from the Administration Department, two from the Technical Operations Department, and two from the Publications Department, were at work on the problem. A plan of procedure was proposed in an article, "The AIEE Technical Divisions," *Electrical Engineering*, January 1957, pp. 64-7.

Section Growth Awards

The Minnesota Section was awarded the Section Growth Award in the larger than average Sections, and the Virginia Mountain Section in the smaller than average Sections. Second place in the larger than average Sections went to Montreal, and in the smaller than average Sections to the Utah Section. Gavels for first place and certificates for second place were presented to the winners by J. R. Kearner of the Sections Committee. This year, the break point between the larger than average Sections and the smaller than average was 457. The Standard for Recognition of Section Meetings and Definitions of Terms and Conditions were explained by H. H. Sheppard, vice-chairman of the Sections Committee.

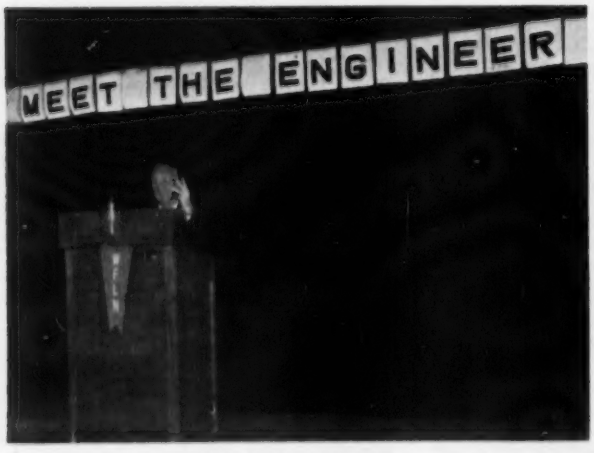
Institute and Section Finances

President-elect W. J. Barrett reported that the Institute finances were in pretty good shape and for two years past, $180,000 had been cleared each year with $1.25 million in reserve. The formation of technical groups in the Sections as recommended by the consultants was encouraged. This would require the expenditure of more money. Reference was made to Past-President Coover's letter (*Electrical Engineering*, June 1957, p. 516) which explained that the Institute was primarily a technical and scientific organization.

Based on an extensive study and survey of the Sections, an analysis and report on Section finances was presented by J. W. Bennett, chairman of a Subcommittee for the Study of Section Finances and Allotments. The recommendations made led to an increase in Section allotments on an interim basis for the forthcoming year. The work is continuing and the Sections may be asked for more information as the study progresses.

Student Branch Activities

In opening this important subject, W. B. Morton, chairman of the Student Branches Committee, explained that the present number of enrolled students does not compare with records three years ago because enrolled students are immediately transferred to the grade of Associate Member upon graduation and over 1,060 were in this category. One Branch has established a



AT THE PUBLIC RELATIONS WORKSHOP during the Section Delegates Meeting, T. H. MacCauley of the Philadelphia Section explained the "Meet the Engineer" series of broadcasts which acquaint the listening public with the engineers' work. To emphasize the number of broadcasts the Philadelphia Section has sponsored, Mr. MacCauley arranged the display (above, *left and right*) of over 100 broadcast manuscripts.

letter of introduction to the secretaries in the territory where students will be located after graduation. Students should be assisted by the Sections in getting summer work. In conclusion, Mr. Morton urged the early appointment of student activities committees. If they work actively with the branches, rewarding results can be obtained.

Other important business at the conference comprised a brief review of new Sections Committee publications, a discussion of membership activities, and transfers. In the afternoon, the tools and procedures to obtain good public relations were outlined by Fischer Black in a public relations workshop. Sound procedures and the use of the publicity kit were explained by R. C. Mayer, Jr., of the Institute's Public Relations Counsel. The series of weekly broadcasts, "Meet the Engineer," which have been successfully sponsored by the Philadelphia Section for some time, were briefly outlined and animatedly illustrated by T. H. MacCauley.

A cordial welcome to the delegates was extended by Past-President Coover who opened the meeting. In opening the afternoon session, he commented on material of a local news nature. No topic is of more interest than the one that we are going to exhaust our supply of fossil fuels in the future. Vice-Presidents visiting the Sections who have stressed this theorem and introduced the interest in high level energy fuels or atomic energy have obtained good publicity. Photographs should be available and the time element should be anticipated. In conclusion, the delegates gave a rising vote of thanks to Dixon Lewis, chairman of the Sections Committee, who presided.

DIXON LEWIS (*left*), chairman of the AIEE Sections Committee, presents a certificate for second place in Section Growth of the larger than average Sections to R. A. Boyd (*right*) of the Montreal Section.

AIEE Board of Directors Meets at Montreal, Que., Canada

IN ANTICIPATION of a possible vacation from the usual August meeting, the AIEE Board of Directors tackled one of the heaviest agendas ever attempted in a one-day meeting on Friday, June 28, 1957, in Montreal, Que., Canada. So great has become the demand for meeting rooms and the scheduling of meetings of subcommittees, conferences, and Departments at the Summer General Meeting that the Board has abandoned its traditional Thursday meetings to make room for the growing need for accommodations for those intent on doing Institute business on this convenient occasion. It was only a few years ago that the Board frowned on the intrusion of too many technical sessions on what were intended to be primarily social summer meetings. Not only the technical sessions, but also the administrative business of the Institute has now crowded aside golf, tennis, and other attractions of the pre-war summer meetings to a degree that would have been considered distressing a generation ago. Maybe there is cause for alarm in this mad pace but if so, nobody seemed to be worried about it at Montreal.

As for the Board meeting itself, it was attended by all except 2 of the 27 voting members. In addition, there were 14 invited guests: 6 incoming vice-presidents, 3 incoming directors, a past-president and several Department heads. There would have been 2 more except that 2 of the Department chairmen are also incoming directors. There were 82 distinct items of business on the agenda. All were considered and disposed of by one means or another. The departmental organization with its decentralized authority opens channels for delegation not previously available to the Board.

Finances

The Treasurer reported that at the end of the fiscal year April 30, 1957, the margin of receipts over expenditures in the general fund, on a cash basis was $174,848.41. As the Auditor's Report shows in the August issue of *Electrical Engineering*, accounting on the accrual basis yields about $11,000 more in this item.

On recommendation of the Finance Committee, the Board voted to advance $5,000 to the 1958 Engineers Joint Council (EJC) Nuclear Congress and to appropriate $10,000 toward the initiating of a comprehensive survey of the engineering profession under the joint auspices of Engineers' Council for Professional Development (ECPD) and EJC. Authority was granted to lend up to a half-million dollars to the United Engineering Trustees (UET) for the purpose of acquiring a site on which to locate the proposed new United Engineering Center.

The Finance Committee submitted to the Board a comprehensive report of the financial position of the Institute with recommendations for future fiscal and investment policy.

Constitution and Bylaws

The Board received preliminary drafts and encouraged the Constitution and Bylaws Committee to proceed with a comprehensive project for restyling and streamlining the statutes governing the Institute. This program is to be carried out in two steps; the first will change the format and wording of the Constitution and Bylaws without changing its substance and meaning. The second step will be to amend and revise the content of these two documents so as to bring them more nearly into line with the current needs of a rapidly developing organization.

Bylaw amendments were approved effecting the following changes:

1. The transfer of the Student Branches Committee from the Professional Development and Recognition Department to the Administration Department, effective August 1, 1957.

2. To establish, in the Professional Development and Recognition Department, a new committee to be known as the Recognition Awards Committee, to be responsible for selecting the recipients of all awards and medals for outstanding achievement in the various fields of electrical engineering that are established by the Institute with the exception of the Lamme and Edison Medals.

3. At the same time, the scope of the Prize Awards Committee was re-defined and extended to give it the responsibility for taking the initiative in creating new forms of recognition and awards for outstanding achievement in addition to its traditional function of awarding prizes for superior papers.

4. A new Bylaw was approved providing that amendments to the Bylaws become effective on the first day of August following their adoption, unless otherwise specifically provided by action of the Board of Directors, in which case, a prominent separate announcement will be made in *Electrical Engineering*.

By special resolution, the board defined in detail the powers and authorities of the Executive Committee of which it is anticipated greater use will be made.

Districts and Sections

The establishment of the Gem State (Idaho) Section was officially announced to the Board as having been approved by the

Administration Department. This Section includes all of the counties in Southern Idaho previously part of the Utah section.

Approval was voted for the division of the Northeastern District No. 1 into two Districts; one embracing New York State as its territory and the other New England. The Empire District which will now be known as District No. 1, will include the following Sections: Ithaca, Niagara Frontier, Rochester, Schenectady, and Syracuse. The Northeastern District to be known as District No. 12 will include the following Sections: Boston, Connecticut, Lynn, Maine, New Hampshire, Pittsfield, Providence, Springfield, and Worcester. D. E. Garr, vice-president of the original District No. 1 will continue as vice-president of the Empire District. Sven Osthagen was elected by the Board of Directors to be vice-president for the new Northeastern District No. 12. This term, beginning August 1, 1957, will be for two years. It was also reported that, as of August 1, 1958, District No. 4 will divide on a north and south line into two new districts. Studies are under way looking toward further adjustments in the territories of District No. 2, 5, and 11.

The Administration Department reported continued growth in Technical Groups. On the basis of reports received from 85 Sections, 57 new Technical Groups have been formed, 4 dropped, and 16 more are in the process of formation which would yield, by August 1, 1957, a total of 220.

A comprehensive study is being carried on by a subcommittee of the Sections Committee for the purpose of establishing a proper basis for Section Financing. On the basis of an interim recommendation, the Board voted to provide additional meeting bonuses for more than 30 meetings per year and also to return to the Sections all entrance and transfer fees attached to applications originating in the Sections.

Admission and Advancement

The Admission and Advancement Department reported the following additions to the several grades of Institute Membership: Fellows—18, Members—286, Associate Members—849, Affiliates—96, Student Associates and Student Affiliates—956. Biographical sketches of the 18 new Fellows will appear in a subsequent issue of *Electrical Engineering*.

The Board voted that engineering graduates of the Instituto Tecnologico y de Estudios, Monterrey, N.L., Mexico; and Escuela Superior de Ingenieria Mecanica Y Electrica, Mexico City, D.F., Mexico, shall be eligible for admission to the grade of Associate Member on the basis of their education. Special Board action is required because ECPD accrediting is not extended beyond the borders of continental United States.

Professional Development and Recognition

The Board approved a contract with the Leeds & Northrup Foundation for the establishment of the Morris E. Leeds Award in Electrical Measurements. It was also announced that a new award or medal has been established by the Phelps-Dodge Foundation to be administered by the Professional Development and Recognition Department in the field of Transmission and Distribution.

Three new affiliate branches have been established as follows: at Christian Brothers College, Memphis, Tenn.; West Virginia Institute of Technology, Montgomery, W. Va.; and University of Wichita, Wichita, Kan.

A Policy Statement

On recommendation of the Professional Development and Recognition Department, the Board approved and adopted as Institute policy the following statement prepared by the Registration of Engineers Committee. Several of the Founder Societies have issued similar statements which are intended to have a bearing on the entire question of "the practice of engineering."

The American Institute of Electrical Engineers endorses and supports the registration of professional engineers as being in the best interests of the public and of the engineering profession, and recommends consideration of registration by its members.

In furtherance of this policy, the American Institute of Electrical Engineers:

(1) Approves the objective of a model Law, offers to co-operate with other sponsoring groups in revisions subject to approval by the Board of Directors, and offers its assistance in the appropriate revision of registration acts where responsible organizations request such assistance.

(2) Supports the objectives and activities of the National Council of State Boards of Engineering Examiners and offers advice and assistance when requested.

(3) Recommends that there be no discrimination, directly or indirectly, as to the form of business organization under which the practice of engineering is conducted provided that the person or persons in responsible charge of such practice be legally registered professional engineers.

(4) Recommends that each Section appoint a committee or representative to co-operate with the State Boards of Engineering Registration or other appropriate agency in the dissemination of information concerning registration in its state.

(5) Recommends that Sections sponsor or co-operate with other groups in sponsoring refresher courses as preparation for written examinations.

(6) Recommends that, upon request, committees and qualified individual professional engineers co-operate with State Boards of Registration in the development of adequate written examinations.

(7) Recommends that each Student Branch devote some time to the subject of professional development with special emphasis on the purpose of registration, the standards required, the Engineer-in-Training Program, and the procedure in applying for registration.

(8) Recommends that the Committee on Registration of Engineers annually sponsor a short informative article on registration of professional engineers to be published in *Electrical Engineering* at an appropriate time.

(9) Recommends that the Committee on Registration of Engineers make available annually a pamphlet giving up-to-date sources of information in the various states and other information of value to students and other candidates for registration.

Technical Operations

The Board voted to authorize the inclusion of travel expenses for the purpose of making available to Special Technical Conferences speakers with special knowledge not otherwise available.

It was voted that the privilege of attending AIEE General and District Meetings with payment of the AIEE member registration fee be extended to all members of cognate societies, as defined by the Board of Examiners for admissions and advancement purposes.

The Board approved establishment of a new policy by which a Technical Division, if it so desires, may be permitted to have Transactions Papers published, after proper review but before presentation. Discussions of such papers, published before presentation or without presentation, will be printed in a subsequent issue of a bimonthly magazine.

The Technical Operations Department made extensive suggestions for bringing together the local Technical Groups in the Sections with the Technical Divisions and Commiteees of the Institute. The Board took these suggestions under advisement and also referred them to the Technical Operations Department, the Publications Department, and the Administration Department for study; and requested the Planning and Co-ordination Committee to bring the findings of these departments together into a final recommendation to the Board of Directors. Meanwhile, the Technical Operations Department was authorized to secure from the Sections the names of all of the Chairmen of their Technical Groups, and to request reports on the activities of Section Technical Groups.

Appointments, Confirmations, and Elections

The Board received for information a tentative list of the appointees to standing

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry,* and *Power Apparatus and Systems,* contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

committees made by the President-Elect. The Board also approved all the recommendations for appointments to Board Committees and for representatives to other bodies. Lists of all of these appointments appear elsewhere in *Electrical Engineering*.

Trips During AIEE Fall Meeting To Be Interesting and Informative

EIGHT SEPARATE TRIPS have been arranged for AIEE members attending the 1957 Fall General Meeting in Chicago, Ill., October 7-11.

Tuesday Morning: Electro-Motive Division of General Motors will be host for a tour through their facilities at La Grange, Ill. In addition to the tour of the manufacturing facilities for diesel locomotives, guests will be given a demonstration of the Electro-Motive mobile diesel-electric generating units called Electro-Mobile Power. The units are designed to boost power in fringe areas of utility systems and to meet peak load demands.

Tuesday Afternoon: A tour to three of the Chicago area's most modern shopping centers will provide a look at the latest electrical service facilities for this type of application. The shopping centers are the Hillsdale Shopping Center, Old Orchard Shopping Center, and Cermak-Plaza Shopping Center.

Tuesday Afternoon: At this time, Commonwealth Edison will display how they use an electronic computer in preparing nearly 12 million bills annually—approximately 50,000 each day.

Wednesday Morning: A tour of the Argonne National Laboratories will feature a look at the atomic Experimental Boiling Water Reactor which was officially dedicated and put "on stream" several months ago.

Wednesday Afternoon: Will County Generating Station is the newest generating plant of Commonwealth Edison Company and is the subject for the Wednesday afternoon tour. Located on the Chicago Sanitary and Ship Canal, the station's first two units—each of 160,000-kw net capability—were placed in operation in 1955. The third, a 260,000-kw net capability, was placed in commercial operation in June of this year. The station can now generate enough electricity to adequately supply a city of 800,000 people.

Thursday Morning: Automatic Electric Company has just moved into its new 1.52 million square foot manufacturing plant in suburban Northlake and the Thursday morning trip will be made through this plant.

Thursday Afternoon: Thursday afternoon's tour will be to the Chicago plant of the Youngstown Sheet and Tube Company to view the processes of making steel.

Friday Morning: The final tour of the Fall Meeting will be to the new headquarters and broadcasting facilities for the Columbia Broadcasting System in Chicago. The new facilities are in a building which formerly housed an ice skating arena but which was completely transformed for its broadcasting duties.

Electro-Motive Div., General Motors Corp.

DIESEL FREIGHT LOCOMOTIVE nears completion at the La Grange, Ill., plant of Electro-Motive Division of General Motors Corporation. An inspection trip to this plant has been planned for Tuesday morning during the 1957 AIEE Fall General Meeting which will be held October 7-11, in Chicago, Ill.

Ladies' Activities

In addition to the daily 9 a.m. coffee hour during the AIEE Fall General Meeting, the women attending the meeting will be entertained at a variety of events. Following is a list and description of each event:

Sunday: Reception in the Cotillion Room in the Morrison Hotel.

Monday: Afternoon, Dessert—Card Party in the Ladies Headquarters in the Walnut Room. This is sponsored by the Delta Star Company.

Tuesday: Luncheon in the Pump Room of the Ambassador East Hotel. Dorothy Bond, a syndicated cartoonist, will speak and she will also do some caricatures of a few in the audience attending the Luncheon. This Luncheon is being sponsored by the Allis-Chalmers Manufacturing Company.

Wednesday: Brunch in the Cub Room of the Morrison Hotel. Betsy Ross, a well known decorator from the John A. Colby Company, will speak on interior decorating. There will be a $3 charge for the Brunch.

Thursday: Luncheon in the Crystal Room of the Chicago Athletic Club. Sulie Harand a well known entertainer will give a musical play. This luncheon is being sponsored by Westinghouse Electric Corporation.

Friday: The program ends with the morning coffee hour.

M. S. Coover Receives Honorary Degree from RPI

In recognition of distinguished careers, Rensselaer Polytechnic Institute (RPI), Troy, N.Y., conferred honorary degrees upon five men at its commencement exercises on June 7, 1957.

Receiving the honorary degree, doctor of engineering, was M. S. Coover, a member of the teaching and administrative staff of Iowa State College since 1935, and past president of the AIEE, 1956-57.

Mr. Coover, a 1914 graduate of RPI, was awarded the degree in recognition of his contribution in the fields of teaching and technology.

His citation listed in the commencement program reads as follows: ". . . at the same time he has been a steady and dependable worker and a leader of vision in such scientific organizations as the American Institute of Electrical Engineers, the Institute of Radio Engineers, the Engineers Council for Professional Development, and the American Society for Engineering Education.

"Throughout his career, he has indefatigably represented the viewpoint and objectives of a teacher dedicated to the development of young men and to higher standards in the professions of teaching and engineering."

Among the other recipients of honorary degrees from Rensselaer was I. M. Stein (F '39), president of Leeds & Northrup Co., Philadelphia, Pa., who was awarded the degree of doctor of science.

Mr. Stein became president of Leeds & Northrup in 1953, having started with the firm in 1919 and been successively a sales manager, research and development engineer, director of research, and executive vice-president.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

Sixth Annual Symposium on Industrial Electronics Planned

Well established during the previous five years, the Symposium on Industrial Electronics, to be held September 24-25, 1957, in Chicago, Ill., at the Morrison Hotel, has become known as THE Conference in the industrial electronics field.

This year's Symposium has as its main theme the characteristics, use, and integration of transducers into complete systems to measure and control complete processes. Sixteen papers will be presented in four sessions, each session devoted to a group of transducers or control systems. The "systems" approach will be stressed in a number of papers.

A number of prominent speakers, nationally recognized for their contributions in the industrial electronics field, have accepted invitations to speak. Dr. J. R. Ryder, dean of engineering of Michigan State University and past president of the Institute of Radio Engineers (IRE), and A. E. Sperry, president of Panellit, Inc., and past president of the Instrument Society of America (ISA), have accepted invitations to address the luncheon meetings on the 24th and 25th, respectively.

The Sixth Annual Symposium is organized by the Professional Group on Industrial Electronics (PGIE) of the IRE and by the AIEE Electronics Technical Committee and is co-sponsored by the Chicago Sections of the IRE and AIEE.

Chairman is W. R. Thurston, General Radio Company, Cambridge, Mass. (PGIE). Conference Chairmen are: E. A. Roberts, Union Terminal Electric Company, Forest Park, Ill. (IRE); and H. A. Barbarino, Armour Research Foundation, Chicago, Ill. (AIEE).

The Program Committee includes Chairman Eugene Mittelmann, consulting engineer, Chicago (IRE); and Co-Chairman Harold Chestnut, General Electric Company, Schenectady, N. Y. (AIEE). Chairman of the Arrangement Committee is J. W. Grant, Tammen & Denison, Chicago.

Moderators of the four sessions are: Richard Jenness, Northwestern University; Tomas Abbott, Standard Oil of Indiana; H. Cornelius, National Harvester Company, Chicago; and Donald Arsen, Stewart Warner Electronics, Chicago.

Among the papers to be presented are:

"A Classification System for Measurement and Control," by E. A. Keller, Panellit Corporation, Skokie, Ill.

"Transmission of Torque Signals from High Speed Machinery," by E. S. Shepard, AiResearch Mfg. Co., Phoenix, Ariz.

"Photo-Electric Registration Control Systems," by J. C. Frommer, consulting engineer, Cincinnati, Ohio.

"Industrial Digital Systems," by E. J. Otis, Daystrom Systems, La Jolla, Calif.

"An Electronic Approach to Sortation Control," by R. W. Burtness, Stewart Warner Electronics, Chicago, Ill.

"Position Transducers for Machine Controls," by J. K. Snell, General Electric Company, Waynesboro, Va.

"Magnetic and Eddy Current Type Transducers for Use in Industrial Electronics," by D. L. Elam, Electro Products Laboratory, Chicago, Ill.

"Pulse Width Control of Transistors," by J. N. Van Scoyoc and R. W. Bull, Armour Research Foundation, Chicago, Ill.

"Accurate Volumetric Particle Size Determination by Electronic Techniques," by R. H. Berg, Process Control Services Company, Chicago, Ill.

Farm Electrification Conference To Be Held in Minneapolis, Minn.

The AIEE Farm Electrification Conference, sponsored by the Farm Electrification Subcommittee of the Domestic and Commercial Applications Committee, will take place October 29-31, 1957, in Minneapolis, Minn. Sessions will be held at the Hotel Nicollet.

The tentative technical program for the conference follows.

Tuesday, October 29

8:30-10:00 a.m. Registration—Hotel Nicollet

10:15 a.m. Morning Session

Chairman: H. W. Kelley, Rural Electrification Administration, REA

Welcome to Minneapolis, S. N. Witts, chairman AIEE Minnesota Section, Northern States Power Co.

Opening Address, official of Northern States Power Co.

Intermission

The Program for the Meeting, H. W. Kelley, REA

Status Report on Farmstead Wiring Handbook and Specifications. *H. H. Watson,* General Electric Company

Expanding Farmstead Wiring. *C. P. Wagner,* North Central Electrical League

2:00 p.m. Afternoon Session

Chairman: T. H. Cline, Newark Stove Company

Theoretical Factors in Rural System Planning. *D. N. Reps,* Westinghouse Electric Corporation

Practical Factors in Rural System Planning. *Harry Dewar,* Patterson and Dewar, Engineers

Intermission

Improving Service Reliability on Rural Lines. L. B. Crann, REA

Loading of Distribution Transformers. Westinghouse Electric Corporation

Wednesday, October 30

9:00 a.m. Morning Session

Chairman: Russell Gingles, NEMA Farm Electrification Bureau

Diversity of Farm Loads. *Landy Altman,* U. S. Department of Agriculture

Characteristics of Electrified Experimental Farm. *L. A. Brooks,* University of Wisconsin

Intermission

The Use of Electricity for Space Heating. *B. H. Martin,* Tennessee Valley Authority

Heat Pump Application on the Farm. *Leon Boyce,* Kansas City Power and Light Company (tentative)

Afternoon Session

Chairman: S. N. Witts, chairman AIEE Minnesota Section

Inspection tour

Thursday, October 31

9:00 a.m. Morning Session

Chairman: J. H. Oliver, General Electric Company

Electrical Safety and Rural Installations. *R. E. Ward,* chief deputy wiring inspector, State of Tennessee

Inflated Temporary Structures for Farm Use. *L. W. McConnell,* Indiana and Michigan Electric Company

Analysis of Secondary Voltages for the Farm. *H. M. Bankus,* General Electric Company

Intermission

Farm Production and Lighting. *Ervin Baker,* Sylvania Electric Products Company

Automatic Handling of Feeds and Silage. *Ralph Bowen,* Wisconsin Power and Light Company

Closing Address

Petroleum Conference Scheduled for Sepember 9-11

The 1957 AIEE Petroleum Industry Conference will be held in Philadelphia, Pa., September 9-11. Headquarters will be the Sheraton Hotel.

The tentative technical program for the conference follows.

Monday, September 9

2:00 p.m. Production Session

M. H. Halderson, chairman, Phillips Petroleum Corp.

CP.* An A-C Application to an Off-Shore Drilling Rig. *G. P. Stetson,* Delta Marine Drilling Company

CP57-984. Classification of Hazardous Areas for Electrical Installations on Barges Employed in Drilling Operations in Lake Maracaibo, Venezuela, *J. C. K. Muhlenberg,* Creole Petroleum Corporation.

CP57-982. Long-Span Transmission Lines for Lake Maracaibo Oil Fields. *R. E. McCollum,* Creole Petroleum Corporation

57-978. Application of Direct Current Machines to Oil Well Drilling. *B. H. Hefner,* Electro-Motive Division of General Motors Corporation

2:00 p.m. Session on Electrical Applications in Pipeline Stations Powered by Gas Turbines

M. A. Hyde, chairman, Westinghouse Electric Corporation

CP57-991. Electrical Control of Gas Turbines in Gas Transmission Service. *R. A. Yannone,* Westinghouse Electric Corporation; *F. P. Goertzen,* Texas Eastern Transmission Corp.; *A. B. Niemoller,* Westinghouse Electric Corporation

CP.* Auxiliary Drives and Power Sources for Gas Turbine Driven Natural Gas Pumping Stations. *J. R. Hoffman.* El Paso Natural Gas Company

CP.* Functional Features of Intermediate Gas Turbine Pumping Units of Trans-Arabian Pipe

* Conference Papers will not be printed by the Institute; however, they may be available at the meeting at the discretion of the author.

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80¢ to Nonmembers

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New York 18, N.Y.

Line Company. *P. P. Nibley,* Trans-Arabian Pipe Line Company; *A. Y. Hillman,* General Electric Company

2:00 p.m. Refining Session

H. M. Stewart, chairman

CP57-973. The Electrical Engineer in the Petroleum Industry. *J. M. Crothers,* Catalytic Construction Company

CP57-989. The Industrial User Analyzes the Power Service. *L. W. Swanson, C. W. Boice,* C. F. Braun and Company

CP.* Electrical Features of the Tidewater Delaware Refinery. *G. E. Harny, R. B. Heckert,* C. F. Braun and Campany

Wednesday, September 11

9:00 a.m. Production Session

M. H. Halderson, chairman, Phillips Petroleum Corp.

CP.* Lease Metering and Lease Automatic Custody Transfer with Positive Displacement Meters. *F. W. Beach,* Cities Service Oil Company

CP.* Lightning Protecton for Equipment Used in Oil Fields. *C. J. Graham,* General Electric Company

CP.* Oil Field Controls for Operation on Voltages between 600 and 100 Volts. *J. K. Howell,* Westinghouse Electric Corporation

9:00 a.m. Session on Pipe Line Electrification Practice

M. A. Hyde, chairman, Westinghouse Electric Corporation

CP.* Application of Large Synchronous Motors in Gas Transmission Stations. *F. P. Goertzen,* Texas Eastern Transmission Corp.

CP57-983. Operation of Fluid Drives in Pipeline Pumping Stations. *F. A. Moore,* The Ohio Oil Company

CP57-987. Protection of Terminal Loading Facilities against Static Electricity. *C. H. Scruggs, D. L. Hope,* Great Lakes Pipe Line Company

CP57-990. Transient Protection Conditions in Pipeline Stations. *E. B. Turner,* General Electric Company

9:00 a.m. Refining Session

H. M. Stewart, chairman

CP57-986. Development of a 75-Mva Refinery Power System Involving Local Generation and Utility Supply. *J. F. Peterson,* Bechtel Corp.; *John Lindquist,* Standard Oil Company of California.

CP57-974. The Economics and Reliability of Electric Motors vs Steam Turbines in Oil Refineries. *L. B. Eddy,* Universal Oil Products Company

CP57-981. Basic Lighting for Petroleum Refining Process Units. *W. O. Mascaro,* Atlantic Refining Company

CP57-972. Economic Justification for Corrosion-Resistant Electrical Materials. *J. M. Bryan* Humble Oil and Refining Company

New Revision of AIEE Standard No. 1

A new revision of Standard No. 1 and new Guides for Thermal Evaluation of both materials and systems, 1D and 1E, have recently been issued by the Standards Committee of AIEE. Co-ordinating Committee No. 4 started this work when new membership was appointed in the spring of 1955. It held its first meeting in 1955 at the Summer General Meeting.

The fact that new materials and new methods of assembly had destroyed the value of the old material classifications to a large degree made it necessary to replace them. At the same time, until necessary approvals of thermal evaluation tests on new materials or new systems can be obtained, provision for retention of the old classifications until superceded is made. If system characteristics are approved and specified by the proper Technical Committees, provision is made for their proof by test in the future.

Already, such specifications have been provided, for motorettes, enameled wire, and dry-type power transformers, for example. Work on other specifications is in process for other rotating machinery and oil insulated transformers. It is hoped that they will be of great value, to permit the use of materials to the best advantage and to provide better knowledge as to the load capabilities of many types of equipment. To take full advantage of these possibilities, it is felt that many years of development work lies ahead for many Technical Committees.

The work is not entirely complete, as one Guide, 1F, has not been completed, but it is hoped that it will be available shortly. It provides for methods of obtaining and analyzing data to obtain the precision desired.

It would be greatly appreciated if the new procedures are studied and commented upon at a technical session which, it is hoped, will to be held in the Fall.

"Computers in Control" Will Be Theme of Symposium

"Computers in Control" will be the theme of a symposium at the Chalfonte-Haddon Hall Hotel in Atlantic City, N. J., October 16-18, 1957. The conference, sponsored by the AIEE Feedback Control Systems Committee with participation by the Institute of Radio Engineers (IRE) Professional Group on Automatic Control and the American Society of Mechanical Engineers Instruments and Regulators Division will feature participation by Tsypkin of the USSR, Pelegrin of France, and Barker and Blackman of England, and emphasize the use of digital and analog computers both as elements of feedback control systems and as utilized in the design of such systems.

The opening session Wednesday afternoon will be followed by a banquet Wednesday evening. Technical sessions on October 17 will culminate in a panel discussion Thursday evening on the topic, "Fitting Computers into Control Systems," with Harold Chestnut, General Electric Company, as moderator and including participation by E. W. Grabbe of Ramo-Wooldridge, T. James of Du Pont, and John Moore of Autonetics Division of North American. Friday morning will be devoted to the closing technical sessions.

A portion of the papers to be presented at the conference are available in preprint form from the AIEE. The Proceedings of the Conference will be published by the AIEE during the first part of 1958. Conference arrangements have been made by a committee consisting of Mr. Chestnut, Mr. Grabbe, Adam Kegel of Westinghouse Electric Corporation, John Ragazzini of Columbia University, and E. Mishkin and Chairman J. G. Truxal, both of Polytechnic Institute of Brooklyn.

AIEE Maine Section Announces New Officers

The third annual afternoon and evening meeting of the Maine Section of the AIEE was held June 19, 1957, with attendance exceeding 150.

The afternoon session included three technical meetings on the following topics: "The Characteristics and Application of Low-Voltage Protective Devices," described by F. J. Shields, General Electric Company; "Cypak Industrial Control Systems," explained by J. B. Baker, Westinghouse Electric Corporation; and "To See Where You Can't Be!" a lecture and demonstration of closed circuit television presented by W. G. Broughton, General Electric Company.

The ladies' program included a demonstration of "The Westinghouse Electronic Oven" by Mrs. Catherine Baird, home service supervisor, Central Maine Power Company.

A social hour and dinner preceded the announcement of the following new officers: C. E. Monty, chairman; C. M. Day, vice-chairman; L. W. Burr, secretary-treasurer; B. T. Payne, assistant secretary-treasurer; W. W. Turner, senior member-at-large of Executive Committee; and G. F. Hart, junior member-at-large of Executive Committee.

The evening address was by Prof. H. R. Brown, Bowdoin College, who spoke on "The 1920s."

COMMITTEE ACTIVITIES

EDITOR'S NOTE: *This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.*

NOTE: Because of the changeover in committee personnel, no items appear in the Committee Activities column this month.

Conference Papers Open for Discussion

Conference paper listed below have been accepted for AIEE *Transactions* and are now open for written discussion until September 26. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electical Engineers, 33 West 39th St., New York 18, N. Y., on or before September 26.

57-496 **Stray Load Losses and Stray Torques in Induction Machines.** *A. M. Odok*

57-530 **Orthomagnetic Current Transformers for Laboratory and Factory Testing.** *L. W. Marks, G. Camilli*

57-532 **The French 380-Kv System Measurement of Corona Losses on Transmission Lines Under Normal Operating Conditions.** *F. M. Cahen, J. M. Carteron*

57-533 **Some Aspects of Surface Voltage Gradient on Power Transmission Lines.** *H. B. Dwight*

57-538 **Analog and Digital Computers in the French Electric Power Production, Transmission, and Distribution Industry.** *F. M. Cahen, J. M. Carteron*

57-575 **Expanding System Requirements Indicate Need for More Severe Arrester Tests.** *G. F. Lincks*

57-608 **Unbalanced Loading of 3-Phase Transformer Banks.** *S. W. Anderson*

57-672 **Economic Comparison of Switched Capacitors and Voltage Regulators for System Voltage Control.** *W. S. Ku*

57-717 **Basic Concepts in the Design of Electric Bus for Short-Circuit Conditions.** *A. C. Bates*

57-720 **Station Control Circuitry with Microwave Relaying.** *B. F. Wirtz*

57-725 **Insulation Phenomena of Compressed Air.** *L. D. McConnell*

57-753 **Transformer Oil Preservation.** *J. R. Meador, N. E. Dillon*

57-805 **Two-Year Lightning Experience on 345-Kv Lines.** *H. L. Rorden, E. S. Zobel, G. D. Lippert*

57-902 **Rating of Autotransformers Having Three Windings.** *E. T. B. Gross, Robert Bolger*

Preprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th St., New York 18, N. Y.

AIEE PERSONALITIES

S. M. Osthagen (AM '47, M '54), district manager in Providence, R. I., for the Allis-Chalmers Manufacturing Company, has been elected by the Board of Directors to be vice-president of the newly created AIEE Northeastern District No. 12 which includes the six New England states. Mr. Osthagen was graduated from Wentworth Technical Institute, Boston, Mass., with a certificate in electrical engineering. For the past 15 years, he has been associated with the Allis-Chalmers Manufacturing Company. Mr. Osthagen has been active in various committees of the Boston and Providence Sections of the AIEE. He was appointed secretary-treasurer of AIEE District No. 1 as of August 1, 1956. He has served on the AIEE Public Relations Committee since 1955. Mr. Osthagen is a member of the Providence Engineering Society and is a registered professional engineer in the State of Rhode Island.

L. F. Hickernell (AM '25, F '34), chief engineer of the Anaconda Wire & Cable Company, Hastings-on-Hudson, N. Y., has been appointed vice-president—engineering of the company. In his new post, he will have full responsibility for directing the engineering, as well as the research and development activities of the company. A graduate of Grinnell College and the Massachusetts Institute of Technology, he joined Anaconda at Hastings-on-Hudson in 1931, and has been chief engineer since 1933. Mr. Hickernell, who is the newly elected treasurer of the AIEE, has been a member of numerous Institute Committees and has served on the AIEE Board of Directors since 1953.

Ernst Weber (AM '31, F '34), vice-president for research at the Polytechnic Institute of Brooklyn, has been appointed acting president. A native of Vienna, Austria, Dr. Weber joined Polytechnic's faculty in 1930 as a visiting professor. In 1931, he accepted the permanent position of research professor of electrical engineering in charge of graduate study. He later became head of the department of electrical engineering. In January 1957, he was named vice-president for research. He will retain his post as vice-president. Dr. Weber holds more than 50 American, Canadian, and British patents in the field of microwave techniques. He was recently appointed a member of the Army Scientific Advisory Panel. He is a fellow of the Institute of Radio Engineers and the American Physical Society. Dr. Weber has served on numerous AIEE Committees.

Morris Rubinoff (AM '52), associate professor in electrical engineering at the University of Pennsylvania has joined the Government and Industrial Division, Philco Corporation, as manager of digital computer engineering. Dr. Rubinoff has served on the AIEE Computing Devices Committee (1954-57).

Wallace Millar (AM '25, M '48), manager for the Construction Industry Division, Canadian Westinghouse Co., Ltd., Vancouver, B. C., Canada, has retired from the company.

I. L. Cooter (AM '42, M '48), acting chief of the Magnetic Measurements Section at the National Bureau of Standards (NBS), has been appointed chief of the section.

Courtesy Roberts Studio
S. M. Osthagen

Courtesy Blackstone Studios
L. F. Hickernell

Ernst Weber

D. E. Aflen (AM '23), vice-president, sales, Anaconda Wire & Cable Company, New York, N. Y., has been elected to the board of directors of the company.

L. D. Barre (AM '52), sales representative for R T & E Corporation in the State of Washington, has been assigned to the position of assistant to the vice-president.

S. L. Chaikind (AM '51), manager of marketing, Standard Electronics Corp., has been appointed market research analyst for the Omaton Division of Burndy Corp., Norwalk, Conn.

R. W. Kunkle (AM '49, M '57) engineering manager, A. B. Chance Co., Centralia, Mo., has been appointed manager of program development of Midwest Research Institute, Kansas City, Mo.

M. A. Moscarello (AM '52), engineering department head, Ford Instrument Company, Division of Sperry Rand Corporation, has been named engineering director for marine equipment.

W. M. Trigg (AM '52), manager of the Westinghouse Electric Corporation's metals development plant at Blairsville, Pa., has been appointed manager of the Westinghouse motor department in Buffalo, N. Y.

R. I. Wilson (M '35), sales engineer, Phelps Dodge Copper Products Corporation, has been appointed Philadelphia (Pa.) district manager and will be responsible for all sales of the fabricating company in that area.

OBITUARIES

Vivian James Foxton Brain (AM '22, M '32), chairman of the Electricity Authority of New South Wales, Sydney, Australia, died recently. Mr. Brain had served as local honorary secretary of the Institute in Australia. He was born in Wollongong, New South Wales, Australia, on August 26, 1896. He received a bachelors degree in engineering (electrical and mechanical) with first class honors from the University of Sydney in 1922. After graduation, he came to the United States where he was associated with the General Electric Company, Schenectady, N. Y., in the construction engineering and the central station engineering departments. He also was employed for a short time in the operating department of the Alabama Power Company. In 1925, he joined the New York Edison Company as assistant engineer in the electrical engineering department. In 1929, after returning to Sydney, he was appointed chief electrical engineer of the Department of Public Works. In 1946, Mr. Brain was appointed chairman of the Electricity Authority and in 1950 vice-chairman of the Electricity Commission, serving in these capacities until his death. Mr. Brain had for many years taken an active interest in a number of organizations associated with the electrical industry. He had been associated with the Electricity Supply Association of Australia since 1929, serving as president, 1942-44. He was a vice-president of the Electrical and Radio Development Association in 1955. Mr. Brain represented the Electricity Authority and the Institution of Engineers, Australia, on the Australian National Council of CIGRE. He was chairman of the Sydney Division of the Institution of Engineers, Australia, in 1935 and president of the Institution in 1951. Mr. Brain was the overseas representative of the Institution of Electrical Engineers, London.

V. J. F. Brain

Noah Steiner Amstutz (AM '02, Member for Life), research engineer and patent attorney, died recently at the age of 92. Dr. Amstutz, a pioneer in the fields of television and facsimile transmission, was born in Smithville, Ohio, on November 5, 1864. During his career, he had served as a member of the faculty of the Valparaiso (Ind.) University School of Law. He received a doctor of science degree from that university in 1947. Dr. Amstutz was a fellow and a life member of the Royal Society of Arts, London, England, and was a member of numerous other scientific organizations.

William Ralph Bullard (AM '16, M '26, F '51, Member for Life), retired electrical engineer, Ebasco Services, Inc., New York, N. Y., died recently. Mr. Bullard was born in Snowville, Va., on September 24, 1892. He entered the General Electric Company Test Course in 1912. From 1915 to 1923, he was associated with United Electric Light & Power Company and the New York Edison Company System. In 1923, he became an assistant electrical engineer for the Electric Bond & Share Company. He was made electrical engineer for Ebasco Services, Inc., in 1935. Mr. Bullard was the author of numerous technical papers and articles. He had served on the following AIEE Committees: Insulated Conductors (1947-57), Transmission and Distribution (1953-57), and Board of Examiners (1954-57).

Laurence Warren Codding (AM '26, M '33), electrical engineer, Ebasco Services, Inc., New York, N. Y., died recently. He was 58 years old. Mr. Codding was born in Massachusetts on January 21, 1899. He was graduated from Massachusetts Institute of Technology with a B. S. degree in E. E. in 1922, and later graduated from Rutgers Law School. After graduation in 1922, he was employed by the Public Service Electric and Gas Company, Newark, N. J. He joined Ebasco Services, Inc., in 1946.

Charles H. Jones (AM '12, Member for Life), vice-president and general manager of the Chicago, South Shore and South Bend Railroad, died recently at the age of 70. Mr. Jones was born in Chicago, Ill., on January 3, 1887. He was graduated from Illinois Institute of Technology in 1909. For 31 years, he had been general manager of the Chicago, South Shore and South Bend Railroad. He had been a vice-president of the line since 1939.

John Andrew Koontz (AM '11, M '20, F '49, Member for Life), consulting engineer, died recently. Mr. Koontz was born in Aztec, N. Mex., August 27, 1883. He received the A. B. degree from Stanford University in 1908 and the E. E. degree in 1912. After graduation, he was employed by the Great Western Power Company, which merged with the Pacific Gas and Electric Company in 1930. He retired in January 1951 and did consulting work until the time of his death. Mr. Koontz was a member of Tau Beta Pi, Sigma Xi, San Francisco Electric Club, and San Francisco Engineers' Club. He had served on the following AIEE committees: Transmission and Distribution (1920-23), Membership (1931-33), and Power Generation (1940-45).

Hudson Roy Searing (AM '20, M '25, F '30), chairman of the board and former president of the Consolidated Edison Company of New York, died recently. Born in New York, N. Y., Mr. Searing was graduated from Cooper Union in 1916 with a B. S. degree in E. E. He began his career with New York Edison Company, a predecessor of Consolidated Edison. He was elected executive vice-president in 1944, and president in 1949. In 1955, he became chairman of the board. Mr. Searing was a member of Tau Beta Pi. He had served on the following AIEE Committees: Standards (1923-25), Safety Codes (1930-31), and Transmission and Distribution (1932-33).

Francis Henry Shepard (AM '07, F '24, Member for Life), retired consulting engineer, died recently at the age of 83. Mr. Shepard was born in Mason City, Iowa. As director of heavy traction for the Westinghouse Electric & Manufacturing Company, a position he assumed in 1903 and held for many years, Mr. Shepard supervised the electrification of several American railroads. In 1932, he left Westinghouse to establish himself as a consulting engineer. He was a member of the New York Society of Professional Engineers and the Engineers Club of New York.

Humphreys Oliver Siegmund (AM '19, M '27, F '45), development engineer for the Bell Telephone Laboratories, New York, N. Y., died recently. He was 61 years old.

CORRECTION: On page 540 of the June 1957 issue of *Electrical Engineering*, the authors of the paper "Inherent Current, Voltage and Speed Control in Dynamo Electric Machinery," listed as Reference No. 1, for the article "Old Ideas and Later Inventions," were inadvertently omitted. They are: J. C. Macfarlane, J. W. Macfarlane, and W. I. Macfarlane. A. Tustin contributed to the discussion of the paper.

Mr. Siegmund was born in St. Louis, Mo., on August 24, 1895. He attended the University of Illinois where he received the B. S. degree in E.E. in 1917 and the E.E. degree in 1926. He joined the Bell Telephone Laboratories as a member of the technical staff in 1925. Mr. Siegmund held numerous patents and was the author of several technical papers. He was a member of the American Physical Society, Sigma Xi, Tau Beta Pi, Phi Kappa Phi, Eta Kappa Nu, and Sigma Tau.

Hugh A. Triplett (AM '18, M '21, F '48, Member for Life), director of research, Littlefuse Co., Des Plaines, Ill., died recently. He was 64 years old. Mr. Triplett was born in Atlantic, Iowa, on March 12, 1893. He was graduated from the Milwaukee School of Engineering in 1915 and received an honorary E. E. degree from the school in 1942. During his career, Mr. Triplett was associated with several firms including Henry L. Doherty Company, Schweitzer and Conrad, Inc., and the A. B. Chance Company. He held numerous patents.

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of July 18, 1957, recommended the following applications for transfer. Any objection to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

Anderson, W. R., associate professor of electrical engineering, California State Polytechnic College, San Luis Obispo, Calif.
Anderson, S. W., engineering consultant, Middle West Service Co., Chicago, Ill.
Antalis, S. J., engineer, General Electric Co., Fort Wayne, Ind.
Astin, J. S., manager, switchgear & control engg., Westinghouse Electric Corp., Sunnyvale, Calif.
Baker, J. F., sales engineer, General Electric Co., Atlanta, Ga.
Barclay, W. L., Jr., transportation supervisor, Westinghouse Electric Corp., New York, N.Y.
Barrett-Smith T. I. member technical staff Bell Telephone Laboratories, New York, N.Y.
Bates, B. W., research engineer, Boeing Airplane Co., Seattle, Wash.
Bergman, E. E., engineering designer, Boeing Airplane Co., Seattle, Wash.
Berkheiser, H. A., division supervising engineer, Indiana & Michigan Electric Co., Fort Wayne, Ind.
Biega, B. C., product engineer, General Electric Co., Fort Wayne, Ind.
Bitringer, P. P., professor of electrical engineering, University of Toronto, Toronto, Ont., Canada
Blankmeyer, W. H., communications engineer, The Montana Power Co., Butte, Mont.
Borchelt, M. L., electrical engineer, Central Power & Light Co., Corpus Christi, Texas
Brown, R. D., representative, Allis-Chalmers Mfg. Co., Spokane, Wash.
Burak, F. J., associate electrical engineer, Public Lighting Commission, Detroit, Mich.
Carroccio, M. J., application engineer, General Electric Co., Fort Wayne, Ind.
Coburn, A. L., Jr., overhead lines engineer, Reynolds Metals Co., Louisville, Ky.
Cratin, P. F., chief, electrical section, U. S. Corps of Engineers, Little Rock, Ark.
Cunningham, G. W., application engineer, General Electric Co., Dallas, Texas
Davis, L. B., engineering & service supervisor, Westinghouse Electric Corp., New Orleans, La.
Dover, C. F., asst. chief electrical engineer, Steel Co. of Canada, Ltd., Hamilton, Ont., Canada
Ellifrit, E. V., division engineer, Commonwealth Edison Co., Dixon, Ill.
Evans, J. H., senior engineer, Southwestern Public Service Co., Amarillo, Texas
Feilmann, C. B., electrical engineer, Iowa Power & Light Co., Des Moines, Iowa
Flora, C. C., secretary cutover committee, Tulsa 4A Project, Tulsa, Okla.
Foelker, H. E., distribution co-ordination engineer, Central Power & Light Co., Corpus Christi, Texas
Goss, W. R., consulting engineer, General Electric Co., Fort Wayne, Ind.
Govindan, T. M., engineer-product service, International General Electric Ltd., Calcutta, India
Graham, F. B., chief, electrical dept., Syska & Hennessy, Inc., New York, N. Y.
Hattrup G. J., supervisory engineer, Westinghouse Electric Corp., Sharon, Pa.
Heigle, W. W., supervisor-manufacturing engg. Cleveland Wire Plant General Electric Co., Cleveland, Ohio
Holloway, W W., engineer, American Tel. & Tel. Co., New York, N. Y.
Jacobson, D., Jr., engineer, Otter Tail Power Co. Fergus Falls, Minn.
Jones, M. W., asst. to dean & asst. professor, University of Virginia, Charlottesville, Va.
Joyner, J. W., engineer, Southern Bell Tel. & Tel. Co., Atlanta, Ga.
Ketteringham, G. R., communication-electrical engineer, USAF, Barksdale AFB, La.
Killoran, J. M., engineer, Cleveland Electric Illuminating Co., Cleveland, Ohio
Klinck, R. W., head, Division of Engg., British Columbia Research Council, Vancouver, B.C., Canada
Lamay, U. R., manager, service engg., General Electric Co., Philadelphia, Pa.
Lauerman, E. J., senior engineer, Salt River Power District, Phoenix, Ariz.
London, S., design engineer, General Electric Co., Fort Wayne, Ind.
MacMorran, W. E., engineering group supervisor, Mountain States Tel. & Tel. Co., Phoenix, Ariz.
Mange, W. E., Jr., division substation engineer, Public Service Electric & Gas Co., Clifton, N. J.
Manke, G. H., chief laboratory & training engineer, Line Material Industries, South Milwaukee, Wis.
Merguer, G. C., Jr., associate scientist, Leeds & Northup Co., Philadelphia, Pa.
Molstrom H. V., engineer Telefonos de Mexico, Mexico D. F., Mexico
Murray, L. B., superintendent of transmission, Alabama Power Co., Birmingham, Ala.
Nolan, W. R., senior engineer asst., Southwestern Gas & Electric Co., Shreveport, La.
Noonon, R. F., electrical engineer, Michigan State University, East Lansing, Mich.
O'Hara, M. B., electrical engineer, Tennessee Valley Authority, Chattanooga, Tenn.
Pendray, T., meter engineer, Tennessee Valley Authority, Chattanooga, Tenn.
Perkins, F. S., superintendent of maintenance & shops, Convair Div., General Dynamics Corp., Daingerfield, Texas
Pfaff, E. W., project engineer, Reliance Electric & Engineering Co., Cleveland, Ohio
Porter, R. A., general meter superintendent, Gulf Power Co., Pensacola, Fla.
Pringle, W. A., manager, industrial motor engg., General Electric Co. Fort Wayne, Ind.
Purser, W. G., Jr., asst. underground distribution engineer, Houston Lighting & Power Co., Houston, Texas
Raney, A. K., application engineer, General Electric Co., Schenectady, N. Y.
Reimers, J. M., general superintendent, Bechtel Corp., Glendale, Ariz.
Robinson, C. T., chief, electrical design section, U. S. Corps of Engineers, Walla Walla, Wash.
Russell, D. R., planning engineer, Idaho Power Co., Boise, Idaho
Russell, P. E., director, Applied Research Lab., University of Arizona, Tucson, Ariz.
Scheideler, A. L., systems engineer, General Electric Co., San Jose, Calif.
Schneider, W. M., district engineer, Southern Bell Tel. & Tel. Co., Inc., Birmingham, Ala.
Schroeder, R. A., electrical engineer, Kohler Co., Kohler, Wis.
Secrist, P. W., design engineer, Bettis Plant, Westinghouse Electric Corp., Pittsburgh, Pa.
Showers, R. M., associate professor of electrical engg., University of Pennsylvania, Philadelphia, Pa.
Simmons, E. J., electrical engineer, Aro Inc., Tullahoma, Tenn.
Steffins, M. R., equipment engineer, Michigan Bell Tel. Co., Detroit, Mich.
Stoj, F. R., project engineer, Weston Electrical Instrument Corp., Newark, N. J.
Stroble, R. L., project engineer, X-ray dept., General Electric Co., Milwaukee, Wis.
Taylor, J. D., manager, equipment & specialty sales, General Electric Co., Atlanta, Ga.
Thomas, M. A., proprietor, consulting engineer, 1178 W. Pender St., Vancouver, B.C., Canada
Uguccini, O. W., chief engineer, National Spectrographic Laboratories, Cleveland, Ohio
Varnfield, C. H., standards engineer, Columbus Southern Ohio Electric Co., Columbus, Ohio
Waggoner, R. M., executive vice-pres. & genl. mgr., Hubbard & Co., Pittsburgh, Pa.
Waters, J. M., professional engineer, Commonwealth Associates, Inc., Jackson, Mich.
Weldy, L. L., owner, 4201 Irving Park Rd., Chicago, Ill.
Werne, G. E., power transmission engineer, Westinghouse Electric Corp., Sunnyvale, Calif.
Woodard, K. A., electrical engineer, Stearns Roger Mfg. Co., Denver, Colo.

80 to grade of Member

Applications for Election

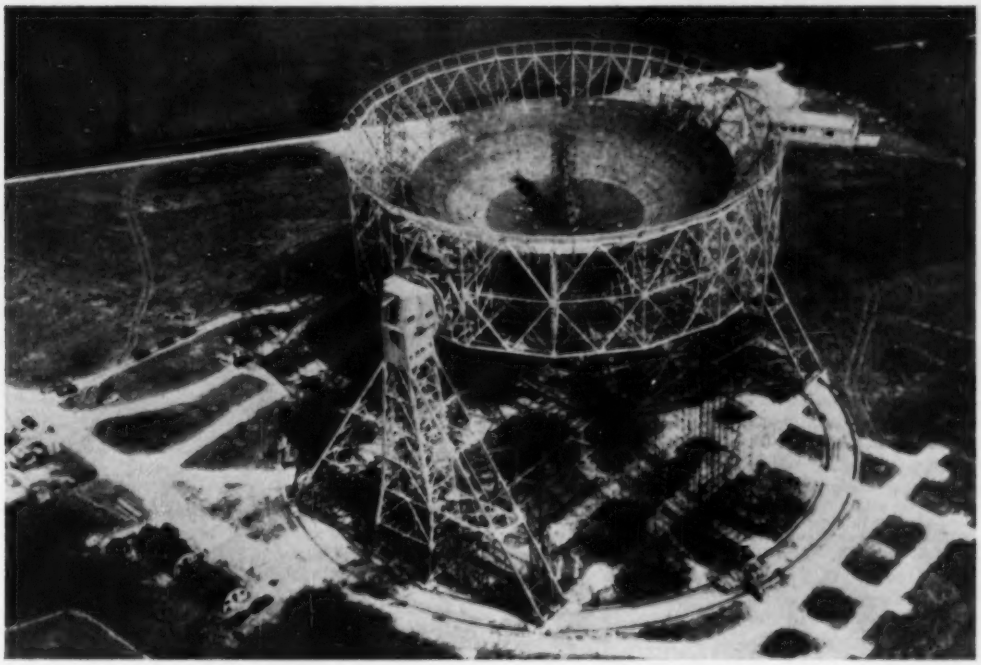
Applications for admission or re-election to Institute membership in the grade of Member have been received from the following candidates, and any member objecting to election should so notify the Secretary before September 25, 1957, or November 25, 1957, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Ackmann, L. E., engineer, Sargent & Lundy, Chicago, Ill.
Anderson, S. P., electrical engineer, Ford Motor Co., San Jose, Calif.
Blair, R. M., electrical engineer, Moloney electric Co., St. Louis, Mo.
Borgman, F., department head-electrical engineering, Giffels & Vallet of Canada, Ltd., Toronto, Ont., Canada
Buehl, R. C., senior development engineer, Rem Cru Titanium Inc., Midland, Pa.
Campbell, J. K., partner, Eadie, Freund & Campbell, Consulting Engineers, New York, N. Y.
Curtiss, A. N., manager, West Coast Electronic Products Dept., Radio Corporation of America, Los Angeles, Calif.
Douglass, M. R., supervising engineer, Westinghouse Air Brake Co., Union Switch & Signal Div., Pittsburgh, Pa.
Erskine, R. A., chairman & managing director, Erskine, Heap & Co., Ltd., Manchester, England
Feng, C. E., senior engineer, Taiwan Power Co., Taipei, Taiwan, China
Ferguson, F. E., chief engineer, Bell Telephone Co. of Pennsylvania, Harrisburg, Pa.
Guay, M. E., partner in General Engineers, Electrical & Mechanical Consultants, Missoula, Mont.
Hasley, A. D., member of Technical Staff, Bell Telephone Labs, Inc., Whippany, N. J.
Kersten, R. S., chief engineer, New Jersey Bell Telephone Co., Newark, N. J.
Ladd, J. H., technical associate, Color Technology Div., Eastman Kodak Company, Rochester, N. Y.
Lee, R. E., senior engineer, Westinghouse Electric Corporation, Baltimore, Md.
McAdams, L. J., maintenance superintendent, Kaiser Aluminum & Chemical Company, Spokane, Wash.
Mihaileanu, C. G., technical director, Electric Power State Department, Arad, Roumania
Nourse, C. F., owner-manager, Nourse Equipment Co., Berkeley, Calif.
Olson, D. R., transmission & protection engineer, Michigan Bell Telephone Co., Detroit, Mich.
Ruina, J. P., research associate professor, University of Illinois, Urbana, Ill.
Tackett, H. A., electronics development engineer, Continental Electronics Mfg. Co., Dallas, Texas

22 to grade of Member

OF CURRENT INTEREST



AERIAL VIEW of radio telescope built for Manchester University to explore the skies by reaching into space a distance of some 1 billion light years and to follow a star in its course across the skies completely automatically.

Courtesy British Information Service

Giant Radio Telescope Is Near Completion in Great Britain

THE GREAT SIZE and uniqueness of the Jodrell Bank radio telescope, the most sensitive short-wave radio receiver yet constructed and also the most far-reaching transmitter, is an example of outstanding engineering skill.

Justification for this great scientific steerable instrument arose from the important results obtained from a 218-foot "fixed" paraboloid reflector facing upwards, constructed of thin wires stretched on tubular scaffolding.

The possibility of producing a full steerable telescope having a reflector as large as could be provided within reasonable limits of expenditure and with the essential requirements that the reflector be sufficiently accurate to deal with radio wavelengths of the order of one meter, with a corresponding accuracy of directional control was the goal set. Subsequently, in order that the apparatus could be used to receive and transmit on wavelengths considerably shorter than one meter, major modifications to the design were carried out.

Problems Involved

The telescope as now constructed has a reflecting surface of steel plates which will be suitably painted to prevent a serious concentration of heat at the focus during solar observations, but at the same time provide a high degree of diffuse reflection to prevent the overheating of the reflecting membrane itself. The reflecting membrane is built up of sheets continuously welded to one another and also continuously welded along their edges to the supporting structure. This form of membrane provides a highly satisfactory degree of electrical conductivity as well as a continuous shield against extraneous radiations from behind the direction in which the telescope is pointing.

The speed of rotation of the telescope and, more particularly, the rates of acceleration are so low that the power required on account of the mass of the instrument is only a small proportion of that needed to control wind forces.

The forces resulting from wind acting on a bowl 250 feet in diameter which might be facing in any direction were a matter of great concern, and vital information was obtained from experimental work carried out by the National Physical Laboratory in a wind tunnel.

Although a maintenance staff is required to look after the telescope, its operation can be completely controlled by one person sitting at a desk carrying all the operating "knobs" and surrounded by banks of instruments giving full information regarding its direction and movements, contained in a building some 200 yards away.

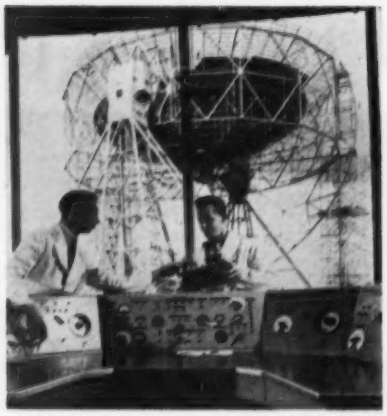
An underground tunnel has been constructed from the basement below the control room to an annular chamber surrounding the center pivot of the telescope. This tunnel is large enough for pedestrian use and carries racks on which the power cables, control cables, and radio cables are laid.

Four major problems faced were: (1) to design a reflector 250 feet in diameter which would keep its shape within close limits during rotation and under the effects of considerable variations of pressure and temperature; (2) to provide a driving mechanism sufficiently powerful to control the telescope under any foreseeable wind conditions; (3) to produce a method of control of the driving system so that the telescope would automatically follow any point in space irrespective of the rotation of the earth and the movement of the earth around the sun, together with facilities for scanning predetermined areas in space and tracking moving objects; and (4) to produce a design which would be carried out by constructional firms and machinery manufacturers, none of whom could have had previous experience in building a mobile apparatus of such magnitude.

The engineering problems can be roughly classified as structural, mechanical, and electrical.

Steel Chosen

Steel was the irrefutable favorite because it has the greatest strength per unit of cost with a relatively low coefficient of expansion; a vital consideration in connection with maintaining reasonable accuracy of shape without use of very complicated temperature compensating devices. Steel



Courtesy British Information Service

CONTROL DESK, showing the many intricate component dials and meters which will gather and record the information garnered from the radio telescope seen through the windows. Size of the steel structure which weighs 2,000 long tons can be realized by comparison with windows of laboratories at sides of axis.

also has a considerably higher modulus of elasticity than aluminum alloys and the greater weight of steel adds stability to the entire apparatus against the overturning effects of wind and also helps to combat the effects of sudden gusts.

Although the total weight of the moving parts—approximately 2,000 tons—is not large when compared with examples of fixed structural engineering, the framework as a whole is a great credit to British workmanship.

There are a number of outstanding mechanical and electrical engineering features. The center pivot holds the telescope on the rails and prevents side movement.

The trunnions and trunnion bearings on which the reflector structure itself revolves and can, in fact, be completely inverted, thus forming the largest domed roof in the world, are of special interest. These are spherically mounted split roller bearings and, like the center pivot, were specially designed for the telescope. Each bearing is capable of taking a combined dead load and wind load of approximately 1,000 tons with a minimum of frictional resistance. The split type of casing was adopted so that the rollers and their cases could be replaced if necessary in the future without a major dismantling of the telescope.

The bogies (weight carrying wheels), on which the 2,000 tons weight of the telescope rotates on specially hardened rails laid to close limits of accuracy, have 48 rollers in all. Each roller bears on two rails and is slightly conical to compensate for the different radii of the tracks. The telescope is driven around its vertical axis by electric motors geared to 16 of the rollers. Electric motors operating through independent gear-boxes also rotate the reflector in elevation, and are situated at the top of the two main bearing towers.

Mechanisms Used

The infinitely variable movements of the telescope on its two axes are achieved by two Ward Lennard type motor generator sets situated in a substation which rotates with the instrument immediately over its center pivot. These generators supply variable amounts of electric energy to the driving motors while the generators themselves are controlled from the combined mechanical and electrical computer system situated in the main control building.

When the telescope is being used to receive radiations from outer space, the amount of energy concentrated on the aerial at the focal points is extremely small. In order to amplify and analyze these radiations before they are dissipated or contaminated by local atmospheric disturbances or man-made radio waves, it is desirable that the radio receiving set, which may roughly be compared to a television receiver, should be located as close as possible to the aerial.

For some purposes, the first amplifier will be immediately adjacent to the aerial at the summit of the 66-foot tower in the center of the bowl; but the main amplifiers are suspended in a steel laboratory hung immediately below the center of the bowl itself.

This laboratory is suspended on trunnions in order to keep its floor level and is equipped with damping devices to prevent uncomfortable oscillations due to the high winds to which it will be subjected. The suspended laboratory can be reached by gangways from the top of each bearing tower, where further high level laboratories travel round with the azimuth motion of the telescope.

Each tower contains an electrical passenger elevator and also a hoist for handling mechanical equipment to the motor rooms. Much of the high level mechanical and electrical equipment was installed under difficult working conditions. Electrical cabling and wiring necessary to couple the telescope to the specially built extension of the Jodrell Bank diesel electric power station and also to connect every vital part of the telescope itself to the control building were installed under similar circumstances.

Shipping Generator Stator Involves Rail, Sea, and Trailer Use

ACCORDING TO THE MAPS, it is only 190 miles from Schenectady, N.Y., to Boston, Mass., but for a giant General Electric Co. generator stator that weighs as much as a herd of 47 elephants, it is a trip of nearly 600 miles by rail, sea, and trailer.

Recently shipped for installation at the Boston Edison Co.'s Mystic River power station, Everett, Mass., was a 467,000 pound stator, which is part of a steam turbine-generator unit rated 140,000 kw by the electric utility.

Details Planned Ahead

Some two years of careful and detailed planning was necessary by traffic personnel in the company's large steam turbine-generator department to insure safe delivery of the electrical apparatus.

Because of the unit's extreme weight and size—it stands over 13 feet high, is some 12 feet wide, and is about 27 feet long—it was impossible to ship the stator directly to Boston because of load-limits of bridges, clearances in tunnels, and construction of railroad rights-of-way.

Railroad Transportation

The enormous stator was pulled from the plant and carried by the Delaware and Hudson Railroad to Jefferson Junction near Binghamton, N.Y., where the Erie Railroad took it over and brought the stator to its Marine Dock in Jersey City, N.J.

Trains on both railroads hauling the special car were restricted to a maximum of 30 miles an hour, and traveled only when the adjacent tracks were clear. The trip to Jersey City took about five days.

Shipping Difficulties

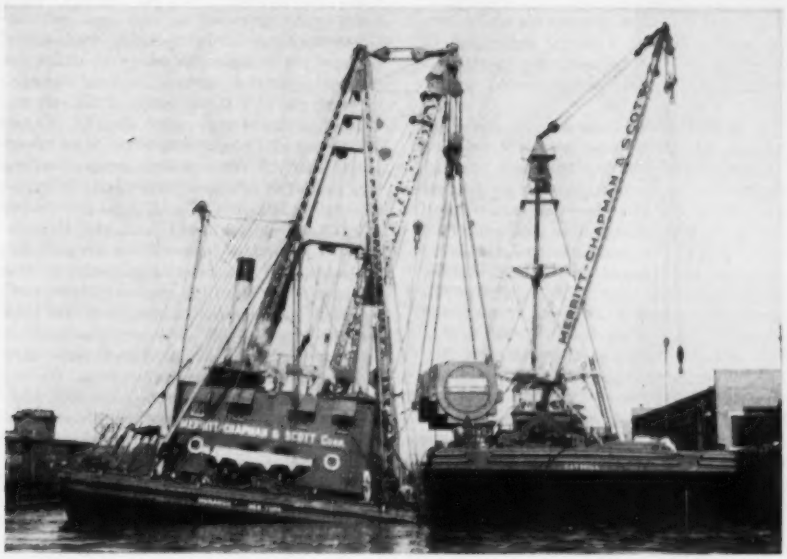
At Pier 1, the only Marine Dock which could bear the load, the stator was lifted off the railroad car and placed on a barge. The lifting chore was performed by the *Monarch*, Merritt-Chapman and Scott Corp.'s derrick which is the most powerful commercial floating derrick on the eastern seaboard.

With one tug towing the barge holding the stator, and another tug towing the *Monarch*, a voyage to Boston via Long Island Sound, Block Island Sound, Cape Cod Canal, and Massachusetts Bay, to Boston Harbor was made.

The entourage then crept up the Mystic River to the Monsanto Chemical Co. dock located near the Boston Edison Co.'s sta-

G. E. Co. Photo

HUGE 467,000 pound generator stator is lowered onto specially designed railroad car which has 16 wheels, 4 trucks, 8 axles, and can transport items weighing as much as 500,000 pounds.



G. E. Co. Photo

TILTED by tremendous weight, the *Monarch*—heaviest lift commercial derrick on the East Coast—uses nearly maximum lifting strength to raise the 467,000 pound generator stator into place on the deck of the derrick *Catskill*. Because of its weight, a regular ocean-going barge was not strong enough, and the *Catskill* was used in this operation because of her reinforced hull.

tion. Here the *Monarch* lifted the stator off the barge and placed it on a special 32 wheel trailer.

Tandem Truck Tow

Thus, the 48 hour chore of moving the stator the remaining mile and a half to the station was begun. Two 300-hp diesel trucks pulling in tandem towed the stator's trailer.

A mile from the dock, the giant crossed Alford Street in Everett, Mass. Some 25,000 board feet of lumber was laid on the street to keep the pavement from breaking up under the stator's weight. This movement was accomplished in the early hours of the morning when traffic is lightest.

Once on the other side of the street, the stator was moved rapidly to the station's apparatus entrance.

Installed Capacity

To better visualize the tremendous power of the complete steam turbine-generator unit when placed in operation, it can adequately satisfy the average yearly electrical needs of some 237,000 persons. Boston Edison Co. is the largest operating electric utility concern in New England and serves 470,000 customers in Boston as well as 39 other cities and towns in the Greater Boston area. The new unit will increase the utility's generating capability to 1,076,800 kw.

Recording of Atmospheric Radio Noise

The National Bureau of Standards (NBS) has set up 16 radio noise recording stations throughout the world as part of the International Geophysical Year (IGY) program. These stations will record radio signals generated by the more than 50,000 thunderstorms occurring daily on earth. This noise recording program, conducted by W. Q. Crichlow, R. T. Disney, and F. F. Fulton, Jr., of the NBS Boulder (Colorado) Laboratories, is expected to increase man's knowledge of radio interference and the propagation of radio waves through the atmosphere.

During the past year the atmospheric radio-noise recorder developed at NBS has been accepted internationally as appropriate for use in a world-wide measurement program. These receivers provide continuous recordings of the average power of the noise received on a standard antenna at 8 discrete frequencies in the range from 15-kc per second to 20-mc per second. In addition, some have been modified to record also the average noise voltage and the average of the logarithm of the noise voltage. It has been shown that these three statistical characteristics of the noise provide a reasonably comprehensive picture of the physical nature of its amplitude distribution.

Some man-made radio noise will also be recorded and studied. However, most of the recording sites will be as far as possible from these sources of interference. For example, one station is installed at Marie Byrd Base in the Antarctic, which is far removed from the radio noise of civilization and from the belt of high thunderstorm activity circling the equator. Information will be gathered at this base about the radio waves that travel long distances through the atmosphere.

The Antarctic site is also an ideal place to study radio noise originating in the sun and the stars. Moreover, the station is inside the auroral zone—the belt around the pole where the southern lights appear dur-

Future Meetings of Other Societies

International Geophysical Year, 10 major physical field co-ordinated investigations, Jul 1, 1957 through Dec 1958, U. S. National Committee, IGY, National Academy of Sciences, Washington 25, D. C.

Peaceful Atomic Energy Uses, 2nd U. N. Scientific Conference, Sep 1-13, Geneva, Switzerland. Information Service, U. N. European Office, Geneva, Switzerland

IUGG, 11th General Assembly, Sep 3-14, University of Toronto campus. Prof. J. T. Wilson, Geophysics Lab. Univ. of Toronto, Toronto 5, Ont., Canada

ISA, 12th Annual Instrument Automation Conference, Sep 9-13, Cleveland (Ohio) Auditorium. Jim Irving, 20 N. Wacker Dr., Rm. 3120, Chicago, Ill.

AIChE, Fall Meeting, Sep 15-18, Lord Baltimore Hotel, Baltimore, Md. J. O. Henry, AIChE, 25 W. 45th St., New York, N. Y.

RETMA (EIA), Numerical Control Systems Symposium, Sep 17-18, Ambassador Hotel, Los Angeles, Calif. J. A. Caffiaux, 11 W. 42nd St., Rm. 650, New York, N.Y.

NBS–Applied Physics Lab. (Johns Hopkins Univ.)–Catholic Univ. of America, Free Radicals Symposium, Sep 18-20, National Bureau of Standards. Dr. A. M. Bass, Free Radicals Research Section, NBS, U. S. Dept. of Commerce, Washington 25, D. C.

ASME, Fall Meeting, Sep 23-25, Hotel Statler, Hartford, Conn. L. S. Dennegar, 29 W. 39th St., 11th Floor, New York, N. Y.

Standards Engineers Society, 6th Annual Meeting, Sep 23-25, Hotel Commodore, New York, N. Y. R. E. Mason, 70 E. 45th St., Rm. 2624, New York, N.Y.

S. P. E., Regional Technical Conference, Sep 27, Hotel Niagara, Niagara Falls, N. Y. R. W. Miller, 3 Hillview Center, Lewiston, N. Y.

Inter-Industry Farm Electric Utilization Council, 4th Annual Power Use Workshop, Sep 29-Oct 1, Shirley-Savoy Hotel, Denver, Colo. W. L. Duncan, c/o hotel.

NACE, North Regional Meeting and Symposium, Oct 1-4, Sherman Hotel, Chicago, Ill. A. B. Campbell, NACE, 1061 M & M Bldg., Houston 2, Texas

International Association of Electrical Leagues, 22nd Annual Conference, Oct 2-4, Sinton Hotel, Cincinnati, Ohio. John Biggi, 155 E. 44 St., New York, N. Y.

AIME (contact Headquarters, 29 W. 39 St., New York, N. Y.)

Society of Petroleum Engineers, Fall Meeting, Oct 6-9, Adolphus, Baker, and Statler-Hilton Hotels, Dallas, Texas

Society of Mining Engineers, Annual Meeting and Southeastern States Mining Conference, Oct 15-18, Hillsboro and Tampa Terrace Hotels, Tampa, Fla.

The Metallurgical Society, Institute of Metals Division, Fall Meeting, Nov 4-7, Morrison Hotel, Chicago, Ill.

Professional Engineers of Oregon, Convention, Oct 18-19, Eugene Hotel. R. A. Carlson, Eugene, Oreg.

Société des Radioélectriciens, Ultrahigh Frequency circuits and Antennas Conference, Oct 21-26, Paris, France. M. Chabrol, 10, Ave. Pierre-Larousse, Malakoff (Seine), France

ing magnetic storms—and thus will provide information on the effect this zone has on radio waves passing through it.

All data from the various stations will be forwarded to the Boulder Laboratories for analysis. The results of this study will not only provide valuable information about radio propagation and meteorology, but also will establish an engineering basis for assigning frequencies to stations.

Another group active in advancing radio noise control techniques is the Radio Interference Technical Committee (RITC). This group was organized in Los Angeles, Calif., primarily as a result of military concern over the increasing problems of radio interference in communication and guidance systems. Members of the organization are employed throughout the United States as specialists in radio interference suppression.

Radio—electronic activity has been vastly increased in recent times, and has brought complex problems of noise interference in spheres ranging from aircraft communications, and transmission for guided missile navigation, to private television sets. It is the aim of the RITC to advance the science of radio interference control through education and exchange of technical information.

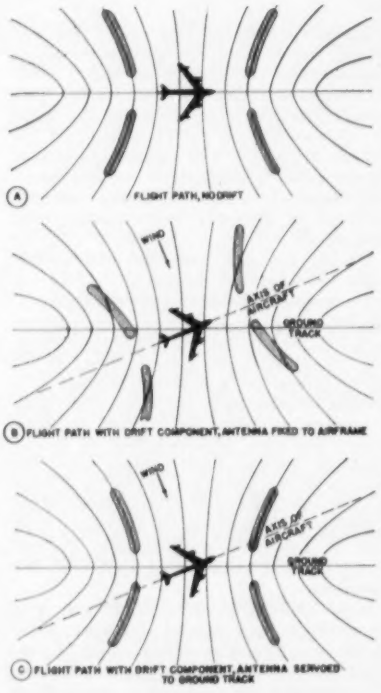
Persons actively engaged in radio interference work are encouraged to join the group because RITC feels that in the more vital field, if radio interference is not suppressed, it causes malfunction of electronic controls, radar, and the like.

Aircraft and Missile Developments in the News

Air Collision Study—A research program aimed at development of a practical anti-collision device has been launched at the Bendix Aviation Radio Division for the Air Research and Development Command (ARDC) of the U. S. Air Force. It is expected that the final device should provide maximum detection range to give ample warning and collision avoidance maneuvering time at closure rate up to Mach 6, surround the aircraft with avoidance information in an essentially spherical shape, include a warning device to inform the pilot of other aircraft in the vicinity as well as specific instructions for avoiding the collision, have an autopilot or flight control system for automatically executing collision avoidance maneuvers, be equipped in space not to exceed 2,500 cubic inches or weigh more than 50 pounds, and have an over-all system suitable for all-weather use in aircraft with speeds up to Mach 3.0 at altitudes up to 100,000 feet.

Dectra Navigation System—"Electronic sky tracks" to ease the squeeze on transatlantic air lanes in a long-range navigation system, now in operation on routes between Newfoundland and Scotland, will be manufactured by the Pacific Division of Bendix Aviation. The system is called Dectra, and operates like a road map in the sky by automatically plotting the exact course of a plane or ship, showing where it has been, where it is at any moment, and its heading toward the desired destination. Another shorter range system called Decca operates in the same fashion, and planes flying the Atlantic will use both the long- and short-range units. Whereas present air traffic control systems require a lateral separation of 120 miles between planes, the installaton of the Dectra-Decca system would reduce this to 30 miles or less.

Doppler Navigation Facts and Figures—The Department of Defense recently released from secret classification the facts and figures that have made history in air navigation where the Doppler system has been utilized. These completely self-contained units operate by transmitting microwave energy to the ground and measuring the return reflection, thus giving the pilot all ground speed and drift angle information needed for navigation. In 1951, the first of these prototype units made by General Precision Laboratory, Inc. (GPL), was installed in a U.S. Air Force *B-29*. Tests indicated that the accuracy was so phenomenal that relaxing some rigid specifications led to the development of another GPL Doppler system called RADAN. These units utilize Janus techniques, i.e., looking forward and backward at the same time. Non-Janus systems require knowledge of the position of the antenna within 1/50th of a degree, whereas the Janus system allows knowing the vertical position of the antenna within 2 degrees to produce the same within 0.1% accuracy, with the *AN/APN-66* unit installed.



DRIFT STABILIZED antenna system (A) is shown, each hyperbola representing a line of constant Doppler frequency return. With a cross-wind, and the antenna fixed to the airframe (B), the two segments of the fore and aft beams will fall on different hyperbolas and, therefore, the Doppler return from the right beam will differ from that of the left beam. This difference is used as an error signal in the *AN/APN-66* system, to keep the antenna aligned with actual ground track (C).

CAA Announces "SCATER" Plan—Procedures to be followed by civil and military Government aviation agencies, and other users of the airspace in the event of an air defense emergency were announced recently through the U.S. Department of Commerce. The Plan for the Security Control of Air Traffic and Electromagnetic Radiations During an Air Defense Emergency (SCATER) was prepared jointly by the Civil Aeronautics Administration (CAA), U.S. Air Force, Civil Aeronautics Board, and the Department of the Navy, in co-ordination with interested civil aviation organizations. Its purpose is to "establish responsibilities, procedures and general instructions for the security control of civil and nontactical military air traffic, air navigation radio aids and aeronautical communications during an air defense emergency which will provide maximum utilization of aircraft by military and civil agencies engaged in essential operations." Copies of the SCATER Plan are available on request from CAA, Press and Publications Staff, Washington 25, D.C.

Sky Platforms—The AC Spark Plug Division of General Motors Corporation is producing a device called "sky platforms" which guides missiles or planes thousands of miles over land, water, or ice automatically and with phenomenal accuracy. These guidance devices could be used in airliners and spaceships to provide guidance at any altitude, in any kind of weather, at any speed, and over any distance.

"Floating" Bases To Bridge Atlantic—A chain of bases located between the islands of St. Lucia and Ascension have been established by the U.S. Air Force's ARDC. These floating bases will fill in the missile tracking gap that exists in the ARDC's 5,000-mile missile test range. The range is used to test the Army, Navy, and Air Force long-range missiles. The links are six "telemetry ships" which have been modified with special electronic equipment to record and transmit data about missile tests to Cape Canaveral, Fla.

Jet Engine Vibration Monitored in Flight—Safer trips for jet travelers and greater mission reliability for military pilots has been assured through the development of a simple electronic device which routinely picks out and measures selected vibrations within the inner recesses of jet power plants, both in flight and on the ground. Measurements are made of both turbine and propeller shaft vibrations when used on turboprop aircraft. The unit withstands 500 F heat as well as −65 F cold. A two-channel amplifier with two high-pass filters has one filter set at 135 cycles to exclude the vibrations made by the low rotor section in order to check only the high-frequency vibrations identified with the turbine, bearings, and accessories. American Airlines will install the Sperry developed monitor aboard its Lockheed *Electra* propjet and its Boeing *707* turbojet planes throughout its network. A warning light flashes if vibrations exceed prescribed limits. Vibration signals are amplified and translated so that the information is available to the crew on a dial set in the instrument panel in the cockpit.

Prospecting with Aerial Color Photographs—High-altitude portraits of mountainous and jungle regions taken with color film gives a bird's eye view of the earth structure in the United States and South Amer-

ica thus supplying geologists with direct clues to mineral deposits, which would take years to find on foot. Air survey teams are busy mapping regions for new highways and looking for minerals all over the globe. Airplanes of the *P-38* type are used in the high-altitude technique by the survey teams of Hycon Aerial Surveys, Inc. Color film is used because color tones, undetectable in black-and-white photography, denote geological characteristics which aid in pinpointing oil and mineral deposits. Subtle color shadings in large areas of rock often reveal invisible deposits. Three-dimensional viewing equipment is used in studying the photographs.

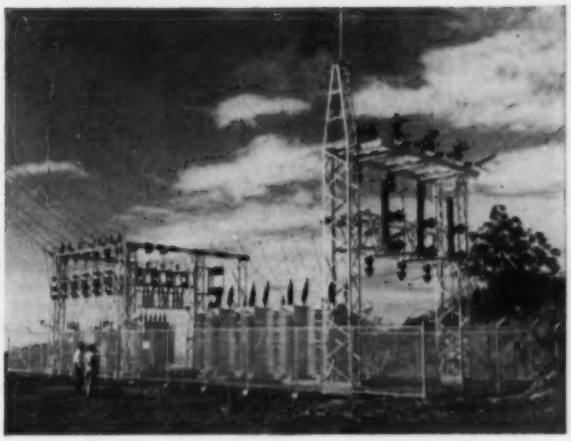
Air Defense Weapon System—The successful development of a versatile air defense missile system designed to reinforce the low-altitude capability of United States' air defenses has been announced by the Department of the Army. Designated the HAWK, the new air defense weapon system will carry a lethal, modern war-head capable of destroying attackers flying at even the lowest altitudes at ranges insuring effective protection of defended areas. The HAWK will complement the high-altitude NIKE system.

Radar Maps Made in Flight—Air navigation may be revolutionized by a device called a radar strip recorder which presents a photograph of the ground beneath an airplane as seen by airborne radar eyes. Pilots and navigators will be able to utilize the information thus garnered to navigate with pinpoint accuracy, instead of depending on memory or hasty notes and calculations. The device needs no operator, combining electronics and photography to determine with ease, the airplane's exact position and true flight path at any desired time in flight without relying on memory or radio equipment on the ground. An actual photographic record of radar information is made on a slowly moving strip of film which is 9½ inches wide. The observer looks at a transparency over a viewing screen and is able to see an image 9 by 12 inches. The transparency pictures the ground immediately aft of the airplane, exactly as it looked to high-precision radar just 20 seconds previously. The film picture does not change, but the long strip of film is slowly wound from one spool to another. A permanent film record of the flight path results, and an accurate picture of the ground below which is reliable both day or night is available to the pilot, navigator, or observer.

Cracking the Aviation Human Barrier—Scientists and specialists from industry and education are preparing an experiment which seeks to crack aviation's "human barrier." Psychologists, biologists, electronics and communications engineers, an endocrinologist, and a physician are setting up the project to test the endurance of pilots and crew members on extended flights. With the development of aircraft capable of sustained flights of long duration (potential nuclear airplane) at supersonic speeds and high altitudes, as well as under environmental conditions never heretofore encountered, human factors must be given greater consideration. Advanced weapons systems performance capabilities approach and, in some instances, surpass the limits of human capacity. Thus, it is imperative to learn more about the limits of human endurance and capability, and to design future weapon systems within the capability of the user. Although normal airplane flights seldom exceed 12 hours, the experiment test crews will be confined in a full-scale mock-up for periods of 120 hours each, while the experts on human behavior investigate the effects of keeping a 5-man U.S. Air Force crew in so small an area for so long a time. The Georgia Division of the Lockheed Aircraft Corporation is the site of these experiments.

Human Engineered Command Station—Flying supersonic missiles from ground command stations is similar to driving a car from a mile behind with a rubber steering wheel. After two years of experimentation and research, the first completely "human engineered" command station has been put into use at Holloman Air Development Center, where the *X-7* ramjet and other missiles are flown. To shorten this steering lag, the new command station will: (1) cut the chances of human error to less than half those of the best previous stations; (2) compensate for the loss of "feel" that plagues the long-distance missile operator by making it possible for him to know at a single glance the speed, pitch, and acceleration of the "bird"; and (3) present a scientifically arranged set of instruments and controls, each analyzed, designed, and positioned by a team of experimental psychologists and engineers. The station, with only 13 instruments, supplies almost 100 pieces of information to the controller and his assistants.

Missile Re-entry Problem Research—An Air Force research rocket, the Lockheed *X-17*, has reached the highest speed ever achieved by any instrumented missile, it was recently disclosed by the Department of Defense. The 3-stage rocket is the biggest and most powerful missile in existence in the United States, and is designed to aid in overcoming one of the most baffling obstacles in the missile development program, that of the classic re-entry problem, which prevents long-range missiles that travel out of the earth's atmosphere in a high arc to their destination from burning up like meteors when plunging back into the heavy air close to the earth's surface. The high rate of reliability attained by this latest of test rockets has confirmed calculation and been instrumental in showing the way to a satisfactory solution relatively inexpensively.



SUBSTATION, first 69-kv transmission line, on the Island of Hawaii. All apparatus for the tie-line was supplied by General Electric Company.

Island of Hawaii Served by 69-Kv Line

The island of Hawaii is now served by the first 69-kv transmission line in this Pacific archipelago.

The new system brings electricity to sparsely settled regions in the interior of the island for the first time, and furnishes additional power to meet rising loads in the Kona area on the western shore. Essential apparatus was shipped in time to handle heavy loads during the island's coffee harvest.

Equipment shipped included high voltage switchgear, medium voltage substations, power transformers, distribution transformers, feeder voltage regulators, lightning arresters, and instrument transformers.

The new transmission line—longest in the Hawaiian Islands—extends more than 100 miles and follows the steep, tortuous Saddle Road between two towering volcanoes, the 13,784-foot Mauna Kea and the 13,680-foot Mauna Loa.

Ultimately, the line passes through the Parker Ranch, one of the largest cattle ranches in the world. Radial lines branch off to bring electricity into the isolated little villages of Pohakuloa, Waikii, and Puuanahulu.

From a Y-point substation in the Hohala District in the northwest of the island, the line connects with the Waimea substation in the north and the Kailua substation on the west central coast.

The new system will be an important factor in the growth of the island's two most important industries—coffee and tourism.

Electrified functions in harvesting and processing coffee beans include preliminary grinding, drying, hulling, sorting, and bagging. Electric motors are also required to drive roofs back and forth over coffee-drying platforms for protection against squalls.

The need for more power on Hawaii led to the merger of the Kona Light & Power Company with Hilo Electric Light Company, forming a single utility for the entire island.

The merger was followed by Hilo Electric's decision to retire obsolete diesel-

generator power at Kailua, Kona, on the Bay of Kealekekua, and to furnish the west coast system of the old Kona Light and Power Company by the 69-kv tie-line.

The tie-line was planned and installed under the leadership and direction of W. H. Hill, president of Hilo Electric; William MacKenzie, general manager of the utility, and Norman Lyman, general superintendent of plants. General Electric Company application engineers C. L. Phillips and G. B. Gilcrest assisted in the design and installation work on the all GE supplied equipment.

Remote Control for Television-Radio-Phonograph

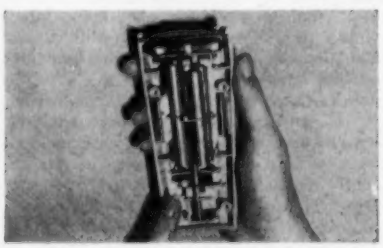
A new wireless remote control that performs 11 functions on a high-fidelity television-radio-phonograph combination was demonstrated by Admiral Corporation recently.

R. D. Siragusa, president, said that the device was developed in the company's Chicago research laboratories after three years' work.

Operating through ultrasonic waves, Admiral's exclusive *Son-r* (pronounced sonar) dual remote control can turn the television set on, adjust the volume to four different levels, change stations, turn on the automatic record changer, reject records, turn on the AM or FM radios, and turn off the television, radios, or phonograph, as the case may be.

The new remote control does not require tubes, transistors, batteries, lights, or cable connections. Its high-frequency sound waves (38,000 to 42,000 cycles) are picked up by a microphone in the receiver and fed to an amplifier activating the relay system that operates the controls.

The lightweight Son-r remote control is held in the hand and activated by pushing a button. One setting on the control wheel is for ON-OFF, another is for switching from television to phonograph or radio, a third is for changing channels or rejecting records, and the fourth setting provides four different volume levels on the television, radios, or phonograph.



Admiral Corporation Photos

INTERIOR VIEW of newly developed Son-r, seen above, shows finger pointing to the clapper which strikes a rod, emitting signals in the 38,000- to 42,000-cycle frequency range. Wheel at the top of the mechanism controls this device. This recently demonstrated wireless remote-control unit, seen at left, operates a high-fidelity television-radio-phonograph combination console, utilizing 11 different functions at the touch of a button.

Co-operative Project Discovery of Element 102

A joint research effort by scientists from the United States, Great Britain, and Sweden has led to the discovery of Element 102.

The joint international research team included scientists from the Chemistry Division of the U. S. Atomic Energy Commission's Argonne National Laboratory at Lemont, Ill., the Chemistry Division of the United Kingdom's Atomic Energy Research Establishment at Harwell, England, and the Nobel Institute for Physics in Stockholm, Sweden.

Announcement of the discovery was made jointly recently by each of the three institutions in the United States, Great Britain, and Sweden.

The new element was produced by bombarding curium, which is Element 96, with carbon ions accelerated in the cyclotron at the Nobel Institute.

The scientists who took part in the experiment—the first to lead to the discovery of an artificially created element by an international research team—are:

From Argonne, P. R. Fields, a group leader in the Chemistry Division, and A. M. Friedman, who is working at Harwell for one year under an exchange of U. S. and British nuclear scientists; from Harwell, John Milsted, a chemist who last year did research work at Argonne under the U. S.—U. K. exchange program and helped separate the curium used in the bombardments and Alan Beadle, a chemist; and from the Nobel Institute for Physics, Hugo Atterling, physicist; Wilhelm Forsling and Lennart Holm, chemists; and Bjorne Astrom, physicist.

The United States, through the Argonne National Laboratory, provided the very rare isotopes of curium used in the experiments. The curium was shipped to Harwell where Friedman, Milsted, and Beadle prepared the targets for the experiments. Harwell provided a rare isotope, carbon-13, which was used as the bombarding particle. The Nobel Institute provided the cyclotron, some special equipment, and a staff of physicists, chemists, and technicians. The co-operation with Nobel Institute was started because the cyclotron at the Institute could provide the intense source of high energy carbon-13 ions which were necessary for the experiment.

The three-nation group began experiments in the cyclotron in March. First indications that the new element had been discovered were found a few days later. The element was recognized by its unique nuclear properties—half life and radiations—and by its chemical properties.

The group performed another series of experiments in April which confirmed the original findings. Similar experiments have just been concluded confirming again the original discovery. At the suggestion of the American and British scientists, the name proposed for the new element is Nobelium.

This isotope of Element 102 thought to have an atomic mass number of 253 is very unstable, having a half life of 10 to 12 minutes and emitting alpha particles. The preparation of the element and a study of its properties extends man's fundamental knowledge of matter.

The target material which was bombarded in the cyclotron was in the form of a thin film of curium on an aluminum foil, placed in a specially fabricated probe in order that the recoils from the nuclear reactions could be caught on clean foils and identified rapidly. For the best results, thin organic foils were used as catchers for the recoil atoms. These foils were dissolved in a drop of acetone on a platinum plate, which was flamed to give a thin source for pulse analysis. The platinum plate was treated with hydrochloric acid to put the activity in solution which was then passed through a standardized ion exchange column. Alpha-hydroxyisobutyric acid was used to extract the new element from the column.

A scientific paper is being prepared on the discovery for publication soon in a scientific journal.

Pump–Turbine for Additional Power in Brazil

A counterclockwise, adjustable blade axial flow reversible pump–turbine has been ordered by Canadian–Brazilian Services, Ltd., purchasing agent for Sao Paulo Light, South America—Servicios de Electricidad, to be installed in a vertical setting in the Traicao Pumping Plant near Sao Paulo, Brazil. This unit will supplement two identical pump–turbine units to furnish additional power for increased power demands in the Sao Paulo area. Number one unit in the plant, manufactured in 1938, was the first reversible pump–turbine to be installed in the Western hemisphere. The original design of these units was perfected on the pump–turbine testing stand in the S. Morgan Smith Company's hydraulic laboratory at the main plant in York, Pa., manufacturers of the units.

The Traicoa Pumping Plant is located on the Pinheiros Canal, and is one of a series of low head pumping plants connecting the Tiete River with the Billings Reservoir. This reservoir supplies water to the high head Cubatao Power Plant at the base of the coastal cliffs, near Santos.

The unit, measuring 138 inches in diameter, is directly connected to a 6,600-hp motor and will operate under a net head between three meters and seven meters. It is guaranteed to pump 1,765 cfs under the seven-meter head at 150 rpm. When generating, it is guaranteed to produce 3,450 hp under the same head. Shipment will begin in the summer of 1958, with completion scheduled for late fall.

During times of low water in the Tiete River tributaries, water must be re-released from the Billings Reservoir for irrigation and general municipal purposes; under these conditions the pump–turbine operates in the reverse direction as a turbine and generates power. When the unit is not required as either a pump or a turbine, the water can be depressed from the runner passages with compressed air; then the unit can be operated as a synchronous condenser to improve the power factor of the system.

These pump–turbines may also be used to pump water into storage reservoirs during off-peak hours. The water may then be released to operate the unit in the reverse direction as a turbine when system load demands are at their maximum.

Vanguard Computing Center Opened in Washington

The Vanguard Computing Center, where high-speed electronic calculations will predict future orbits of U. S. scientific earth satellites, opened at 615 Pennsylvania Avenue N.W., Washington, D.C., on July 2.

The center will be operated under a U. S. Navy contract by International Business Machines Corporation (IBM), using an IBM *704* Electronic Data Processing System. The machine's computing units are rigged to whip out complicated calculations fast enough to anticipate the paths of a tiny artificial satellite hurtling around the world every 100 minutes.

The *704*, which will calculate the satellite orbits, is magnetic tape operated. Not only is tape used for data storage, but it is also the primary means of input and output to and from the heart of the computer.

Information flows in and out of the central unit via tape at the rate of 2,500 words per second, and as many as three tapes can be read at once.

Some of the toughest problems in establishing earth satellites for scientific research during the International Geophysical Year (IGY) will concern proving that the satellites are orbiting, measuring these orbits, and subsequently predicting future orbits.

Initial U. S. satellites, planned for launching under Project Vanguard, will be 20 inches in diameter and will speed at more than 18,000 miles per hour in an elliptical course at altitudes of from 200 to 1,400 miles above the earth.

Initial acquisition and later tracking of the man-made moon by radio techniques will be assigned to a "Minitrack" system, designed by the Naval Research Laboratory. (See pp. 666-72 in August 1957 *Electrical Engineering*.)

A subminiature radio transmitter with battery power enough to operate for several weeks will be installed in the satellite to reach antennas of ground tracking stations.

AT VANGUARD Computing Center, a group of scientists, (left to right) Dr. J. W. Siry, Dr. Paul Herget (seated), Hugh Chrisman, and J. J. Fleming, from the Naval Research Laboratory examine an overlay on which the IBM *780* Cathode Ray Tube Output Display at left will trace the path of the artificial earth satellite on the earth's surface. The Output Display is a special television tube which pictures the calculations of the IBM *704* electronic computer in the form of charts, figures, or special engineering symbols.

These Minitrack stations, to be manned chiefly by Army personnel, but also using Air Force, Navy, and civilian technicians, will be the satellite's radio link with earth.

As the satellite crosses the area of these stations, they will measure its angular position by phase comparison techniques, recording its "signature" automatically. Analysis of these signatures will give the complete orbital history of the satellite's passage. These data will be flashed to the Vanguard Control Center at the Naval Research Laboratory. Here they will be relayed to the Vanguard Computing Center for the complicated job of calculating and compiling satellite ephemerides (timetables of the expected locations of the satellite at regular intervals during its future life).

It will be these schedules, when signaled to optical tracking stations around the world, which will allow watchers to train their instruments at the right place and time for precise observation of the tiny, speeding, artificial moon.

The Smithsonian Astrophysical Observatory at Cambridge, Massachusetts, has been assigned satellite optical tracking programs by the IGY Satellite Committee of the U. S. National Committee for the IGY. The USNC/IGY was formed by the National Academy of Sciences, with co-operation of the National Science Foundation.

The Vanguard Computing Center, considered the heart of the Minitrack system, will be in testing operation as facilities are completed in the Americas, in the West Indies, and in Australia. Communications with the distant stations, through special facilities at the Naval Research Laboratory, which is in turn connected by landline to the Vanguard Computing Center, will get exhaustive checks in preparation for satellite launching attempts during the IGY.

Flat Image-Producing Panels for Varied Applications

The production of images on flat panels, by combining the sciences of lighting and electronics, was announced recently by F. J. Healy, vice-president in charge of Sylvania Electric Products Inc.'s lighting operations. The new development, called "Sylvatron," is believed to have many important possibilities in the future development of radar, air traffic control, computers, instrumentation, and related devices.

Attention is being concentrated on national defense applications and relatively specialized industrial fields. Considerable work remains to be done before the device reaches the commercial production stage, especially insofar as commercial and consumer product applications are concerned.

The new image-producing panels utilize not only this principle of electroluminescence but also the principle of photoconductance, which is the influence of light on the flow of electricity through a solid.

The devices consist of flat glass electroluminescent panels with various control layers. These control layers are thin coatings of photoconductive and electroconductive surfaces.

When electrical or optical signals and a power source are applied to the Sylvatron, a visual display, or image, is produced.

Each of the three types displayed at the conference produces different images. They include: (1) an electroluminescent panel on which the position of a mobile dot of light can be manipulated electrically; (2) a display panel which reproduces optically the track of a mobile spot of light and the image thus created can then be held, or stored, indefinitely in visible form

THE IMAGE-PRODUCING panel is shown being put through laboratory tests by Dr. Keith Butler, manager of the general engineering laboratories of Sylvania's Lighting Operations.

on the panel; and (3) an electroluminescent panel which can reproduce optically a motion picture with good resolution and rapid response.

The operation of these types of panels also varies. In one type, for example, when a-c electricity is applied to the conductive layers and a spot of triggering light is applied to an individual photoconductive element, the photoconductor transmits electricity which causes an electroluminescent dot under the element to light up.

Developed by Sylvania's Lighting Division General Engineering Laboratory, Salem, Mass., the Sylvatron panels thus far have been produced in two-inch and four-inch squares. Development of the units in larger sizes for certain military applications, and electronic circuitry of systems for specific defense applications is being studied.

Part of the work on the Sylvatron developmental program was carried on as a co-operative project between Sylvania and the Lincoln Laboratories operated by Massachusetts Institute of Technology (MIT).

Mr. Healy said that a limited quantity of the Sylvatron devices would be made available to selected laboratories. "By making them available to such laboratories," he declared, "we hope to obtain guidance in the emphasis and direction of our further development work."

Because the panels are "uniquely adaptable" for a number of military systems, the distribution of these laboratory units will be on a priority basis, the Sylvania official pointed out. Larger units are now being developed for certain military applications. The only limitation in size is the size of the production machinery itself.

Coal Pipeline from Georgetown to Eastlake

First shipment of coal moved to the Eastlake, Ohio, generating plant of the Cleveland Electric Illuminating Company recently after being pumped through the world's longest coal pipeline.

Pipeline engineers said the coal was a test shipment and that operation of the pipeline is on a trial basis. Initial tests had been run for a portion of the pipeline as engineers made inspections. This test run was the first time coal had moved through the entire pipeline. Earlier operational problems, which had been anticipated, have been overcome.

Finely ground and mixed with water to form a "slurry," the coal was started on its way from a mine at Georgetown, near Cadiz, Ohio, for the 108-mile trip to Eastlake.

Operating 24 hours a day, the coal pipeline is designed to carry 1.3 million tons of coal a year to keep four hungry turbogenerators humming in the company's Lake County plant located on the shore of Lake Erie, about 22 miles east of Cleveland.

Three pumping stations hurry the slurry along the route. Calculated time for the move from Georgetown to Eastlake is about 35 hours at four miles per hour.

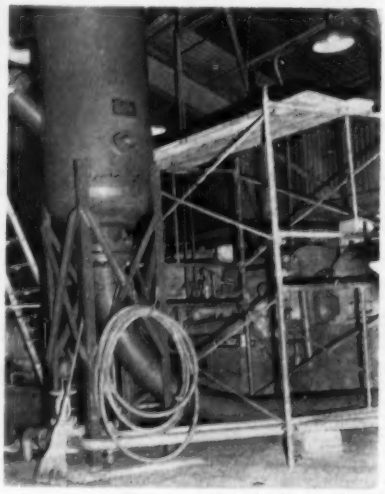


Photo by Tommy Brents

COAL PIPELINE starts here in No. 1 pumping station at Georgetown, Ohio. The pipe at the bottom is the first link in the 108-mile pipeline to Eastlake station.

The pipeline, pumping stations, preparation plant, and drying plant were constructed at a cost of $12½ million by Pittsburgh Consolidation Coal Company, the owner. This is the first coal pipeline in the world longer than 10 miles.

Starting point of the pipeline is at the mine's preparation plant. The coal, first wrenched from the earth by giant power shovels, is crushed and mixed with clear pond water for the trip north.

The pipeline was laid in four months at an average rate of 2½ miles of 10½-inch pipe a day, buried to a depth of at least four feet to avoid freezing conditions.

The furnaces at Eastlake eat up 1.6 million tons of coal a year. The company engineers estimate that the pipeline will supply 80% of the plant's annual fuel needs. Moreover, that represents about 50% of the fuel requirements for the company's entire system. The rest of the coal needed at Eastlake will be shipped in the conventional manner.

A 15-year agreement with Pittsburgh Consolidation for the supply of coal via the pipeline has been made. In addition, at the end of that period, the company will have acquired ownership of the drying plant under a purchase-rental plan which is in effect.

1956 Economic Survey of the World

Although the new climb in world production which began at the end of the Korean hosilities continued, almost everywhere the pace slackened in 1956, according to a world survey made public recently by the United Nations.

According to the survey, the loss of economic momentum originated as much in the realm of government policy as in the area of private enterprise. "World Economic Survey, 1956" states: "Though on balance the outlook appears to be for some continued rise in the coming months, the margin of uncertainty is greater than a year ago."

Some of the main points that emerge from the study of current developments in the world economy are:

1. Although the world economy, as a whole, continued to move forward in 1956, a common concern in all countries was the rising pressure on prices, and in some countries the growing deficits in their balance of payments position.

2. The over-all effect of the Suez crisis was much less serious than was originally feared.

3. Costs rose significantly in most countries as the growth in productivity failed to match the increase in wages.

4. In primary exporting countries domestic production was generally higher in 1956 than in 1955; personal consumption was higher, and there was a significant increase in the volume of resources devoted to capital formation.

5. Demand for commodities of particular concern to primary exporting countries was maintained and prices remained fairly firm.

6. Rapid economic expansion in the centrally planned economies continued in 1956, although slower than in 1955, with output of producer goods increasing in most countries at a higher rate than output of consumer goods.

7. For the second successive year agricultural production rose considerably in the Soviet Union; however, all other eastern European countries experienced a significant decline in their grain harvests.

8. The foreign trade of the centrally planned economies rose more in 1956 than in 1955 and their trade with the rest of the world increased faster than trade with each other.

The United Nations report entitled "World Economic Survey, 1956" is published as Document *E/2982*, and comes in two parts. Part I studies the balance of payments problems during the postwar period, and Part II examines the development of the world economy in 1956. The entire report will be available at $2 per copy from authorized United Nations sales agents throughout the world.

Activities of Other Societies and Organizations

ASME—J. N. Landis has been nominated to the post of president of The American Society of Mechanical Engineers. At the same time, the names of nominees for vice-president and director posts were announced, as follows: *Vice-presidents*, C. E. Crede (Region I), A. W. Weber (Region III), E. W. Allardt (Region V), and H. S. Aurand (Region VII). *Directors*, L. N. Rowley, Jr. (Administrative Activities), E. O. Bergman (Codes and Standards), and R. B. Smith (Technological Activities).

AIME—Three branches were established as societies within AIME at the last annual meeting. They will be known as the Metallurgical Society of AIME, the Society of Mining Engineers of AIME, and the Society of Petroleum Engineers of AIME. It is felt that in this reorganization the fundamental aim of the major society will be fulfilled. J. C. Fox has been appointed secretary of the Society of Mining Engineers upon the resignation of Arnold Buzzalini.

RETMA (EIA)—The name of the organization has been changed from Radio-Electronics-Television Manufacturers Association to Electrical Industries Association. At a recent meeting of the Federal Communications Commission (FCC), J. B. Williams, a member of RETMA, testified on a simple tool for plotting microwave systems (known as "Key Hole"), in allocating frequencies above 890 mc, whereby some 3,600 stations can be accommodated in an area 100 miles square.

Institute of Aeronautical Sciences—The formation of the International Council of Aeronautical Sciences has been announced by IAS. Recently, 16 representatives from 10 nations met in Paris as a Provisional Council of the first world-wide organization formed specifically to extend collaboration in all scientific areas pertaining to mechanical flight. Countries throughout the world, regardless of military or political interests, will have invitations extended to any organized societies dedicated to the advancement of the aeronautical sciences to join ICAS. The Institute of Aeronautical Science will act as the representative society in the United States, and is located at 2 E. 64th St., New York 21, N. Y.

Electro-Chemical Battery Cooperative Association—This corporation has announced the contrary thermodynamic theory on the function of the lead-acid battery. The electrochemical process of sulfuric acid combining with the lead, in the lead-acid battery, and resulting in lead sulfate to create electricity, does not have to remain a normal process, when the final result is sulfation, which is the major cause of battery failure. Electro-Chemical BCA has developed an electrochemical process which prevents and eliminates the cause of sulfation in the normal function of a lead-acid battery.

This method has been field tested in over 7,000 batteries as well as with over 4,000 junked automobile batteries which have been put back into normal automobile service. At its 1139 E. Jersey St., Elizabeth, N. J., location, it has been established that the liquid formula can be produced for general use at a feasibly economic cost.

NACE—A report on hydrogen sulfide embrittlement research has been published by the NACE which is entitled "Hydrogen Absorption, Embrittlement and Fracture of Steel," by A. E. Schuetz and W. D. Robertson. The work was conducted under the auspices of the Technical Committee T-1G on Sulfide Stress Corrosion. The project was four years in completion. Calgary, Alta., Canada, is the newest of six sections organized in the Dominion, and the 53rd one in the entire organization.

True Tracking and Off-Center Positioning Radars

A recent development was introduced as "true tracking" radar by the Sperry Gyroscope Company, demonstrating the first and only adaptable marine radar equipment to combine off-center radar positioning and a panoramic presentation of all moving and stationary objects within range of a radar scanner.

This advanced electronic device and an equally new off-center type radar were demonstrated to the press aboard the company experimental ship *Wanderer*. According to J. L. Hammond, manager of Sperry's marine division, the Mark III radar is the only commercial radar available today that can be adapted in the field for true tracking and off-center presentations. Sperry Mark III equipment is designed to accept these new radar accessories.

Sperry's true tracking radar, virtually presents on the radarscope an aerial "motion picture" of vessels within range of the scanner. True tracking offers to the trained observer immediate differentiation between moving vessels and stationary objects. In a panoramic picture presentation, moving objects, including own ship, appear in perspective as moving blips of light with small, glowing comet-like tails indicating course of travel. Stationary objects, such as land, docks, and buoys are clearly defined, stay fixed on the scope, and have no after glow trails. Although this projection does not completely eliminate plotting, it enables the experienced navigator to "see" instantaneously and estimate true speed and course of all nearby vessels.

An off-center positioning device, also introduced to the press, was initially developed for land-based stations and used for monitoring and controlling river, canal, and harbor traffic. This new feature, now available for shipboard use, allows navigators to position their ships electronically anywhere on the radar picture tube. Off-center positioning not only retains "close-in" definition and resolution of targets, but by moving land masses off the scope, the radar observer can scan a greater area without changing the range scale, according to Sperry engineers. Off-center positioning provides an added safety factor for tow boat operations requiring pinpoint definition ahead of tow; provides coastal ships with sharp definition of shore check points, at the same time permitting the master to detect approaching vessels.

Off-center positioning control (a requirement for true tracking presentation) is a factory or field modification to Sperry's Mark III radar. True tracking is obtained by means of a small computer attachment which resolves ship heading and speed into proper signals.

Four pictures taken aboard the Sperry experiment ship *Wanderer* during recent demonstration along the Hudson River.

TRUE TRACKING RADAR, in 2 left photographs, shows (*left*) superimposed arrows indicating direction of moving targets with afterglow "trails" which stationary ships do not have. Radarscope (*right*) presentation shows location of same targets 2 minutes later. Off-Center Positioning Radar, in 2 photographs right, shows (*left*) conventional radar presentation emphasizing "no traffic" land mass with heavy traffic at edge (West) of scope. Off-center radar (*right*) feature retains land check points (East) but brings ship traffic formerly unobservable onto scope.

Flight Information Automatic Transmission

A system for automatic transmission of flight information from aircraft to ground control centers has been developed by Stromberg-Carlson, a Division of General Dynamics Corporation, and is expected to be an important aid in air traffic control.

This system, called LABIL (Light Aircraft Binary Information Link), enables an aircraft pilot to transmit automatically 13 separate categories of flight information to a control tower with the flip of a switch, according to G. A. Peck, vice-president in charge of S-C's Electronics Division.

Information to be transmitted is entered into the system by the pilot, through adjustment of control selection knobs. It includes such data as identification, departure point, destination, estimated time of arrival, present position, altitude, airspeed, time of report, heading, flight time remaining, and other data. Request of information by ground control, indicated by a visual signal, is answered by depressing a transmit key. Modification of the equipment also will enable the control tower operator to receive the stored information automatically by depressing an identification code key for individual aircraft, without the pilot being required to depress his transmit key.

The entire stored message is then automatically transmitted to the ground control center over the standard voice transmission communication equipment aboard the plane. The information filters through an error detector, and is then passed to a teletypewriter print-out device. Information failing the error check appears as blank spaces in the printed text and is, therefore, identifiable.

Transmission of the message can be made in two seconds if the ground control unit is equipped with a buffer storage device for accommodating the slower speed of the teletypewriter, which requires about 20 seconds to print the data at normal rate.

Microwave Ferrites Developed at Laboratory

Ferrite materials having properties particularly well adapted for a broad range of microwave applications have been developed recently by L. G. Van Uitert of Bell Telephone Laboratories. The desirable properties include controllable saturation magnetization, low dielectric loss, and a high degree of reproducibility.

Many novel microwave circuit elements have grown from the development of the microwave gyrator in 1951. These new devices depend on the high frequency magnetic behavior of ferrites and utilize ferromagnetic resonance in insulating magnetic materials. This and other new applications of ferrites followed a general upsurge of interest in magnetic oxides stimulated by developments at the Philips Laboratories in the Netherlands. The new ferrite materials constitute a forward step in production of the unique nonreciprocal microwave devices in which solid materials themselves perform complex circuit functions, and signify a new microwave epoch in ferrites.

These materials are essentially magnesium, manganese, aluminum ferrites, or nickel manganese ferrite with a small amount of copper replacing some of the magnesium or nickel. The addition of the proper quantities of copper and manganese to the basic ferrite is advantageous from several points of view. By increasing the reactivity of the mixture, copper decreases the necessary firing temperature by at least 100 C. Under comparable conditions this results in lower porosity and improved uniformity in the fired material. The manganese addition decreases electrical conductivity and, thus, the dielectric losses in these low porosity materials.

Microwave measurements on these new ferrites indicate that in general they are comparable to or better than similar materials containing no copper. Applications include microwave gyrators, isolators, and similar devices.

Conquest of Fog Device at Exhibition

In an exhibition sponsored by the Electrical Engineers of the United Kingdom, A. W. Haslett, editor of *Science Today* and *Science News* has made note of the developments reported in the following paragraphs which are of greatest interest to *Electrical Engineering* subscribers.

The atom has thus far proved easier to conquer than fog, in spite of all the efforts of scientists. At the Electrical Engineers' Exhibition recently held in London, there was shown a new British invention which concedes the continuing nuisance of fog and offers one more way to reduce it at sea.

The object is to measure and record continuously the distance which two ordinary human eyes can see effectively in the conditions prevailing. It is believed to be the only equipment of its kind in the world.

Its first use will be to decide when foghorns in lighthouses and lightships should be switched on. But it may also be useful in ships for telling navigating officers when visibility has so far fallen that look-outs can no longer be relied upon, and that recourse should be had to radar.

The automatic fog detector, as it is called, was designed by the chief research officer of Trinity House—the organization responsible for lighthouses and lightships round the British coasts—and has been developed by the British firm of Stone-Chance Ltd., in conjunction with the National Research Development Corporation.

Once every seven minutes, it sweeps a narrow, telescopically sharp beam of light in all directions. At the end of each sweep, the instrument checks the brightness of its own beam and adjusts it to its predetermined value.

When fog particles are in the air, some of the light from the beam is scattered back towards the instrument. This light can be recognized as originating in the lamp that provides the beam; and from the amount that comes back, the distance that the eye can see is calculated. In the control room (which in a ship would be the bridge) the visibility in miles is shown on a meter, and is also recorded continuously on a chart.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries; information for which is taken from the prefaces of the books in question.

RECTIFYING SEMICONDUCTOR CONTACTS. By H. K. Henisch. Oxford University Press, 114 Fifth Ave., New York 11, N.Y., 1957. 372 pages, 6 by 9½ inches, bound. $11.20. An advanced treatise dealing with the following main topics: electronic equilibrium in solids, structure and voltage-current characteristics of plate rectifiers and of point-contact rectifiers, rectifiers as capacitive circuit elements, unipolar rectification theories, theory of injecting contacts, and special contact theories. Introductory chapters cover fundamentals of rectifying systems and the mechanism of charge transport for the benefit of readers not previously engaged in research on solid-state physics. The last two chapters deal with experimental methods. There are 16 pages of references.

RELAXATION SPECTROMETRY. By E. G. Richardson. North Holland Publishing Company, Amsterdam, Netherlands; Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N.Y., 1957. 140 pages, 6 by 9⅛ inches, bound. $5.75. "This text deals with those energetic phenomena which accompany the passage of mechanical displacements through matter" [Preface]. The first chapter is a discussion of the nature of acoustical relaxation sufficiently detailed to provide a background for the principal subjects covered: mechanical and electrical models; the infrasonic, sonic, and ultrasonic spectra; dielectric relaxation; and spectrum analysis. The emphasis throughout is on experimental methods, with only a minimum of theory introduced.

RUSSIAN-ENGLISH ATOMIC DICTIONARY. By E. A. Carpovich. Technical Dictionaries Company, Box 144, New York 31, N.Y., 1957. 317 pages, 5⅜ by 8½ inches, bound. $12. Contains over 23,000 Russian entries primarily in nuclear science and nuclear technology including atomic and molecular physics, pure and applied mathematics, chemistry and chemical engineering, biophysics, radiobiology, medical and biological terms, metallurgy, metallography, uranium geology, thorium crystallography, peaceful and military uses of the atom, general terms, and abbreviations.

SEMICONDUCTOR SURFACE PHYSICS. Edited by R. H. Kingston and others. University of Pennsylvania Press, 3436 Walnut St., Philadelphia 4, Pa., 1957. 413 pages, 5¾ by 8¾ inches, bound. $8. This volume contains the proceedings of the Conference on the Physics of Semiconductor Surface held at Philadelphia in 1955. It is comprised of 23 papers grouped in 4 sections paralleling the sessions of the conference: clean surfaces, real surfaces, adsorption and catalysis, and oxidation. The individual papers present the latest interpretations of surface states, surface conductance, and related phenomena, as well as reports on experimental techniques used to study the properties of semiconductor materials.

SYSTEM ENGINEERING. By H. H. Goode and R. E. Machol. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1957. 551 pages, 6 by 9¼ inches, bound. $10. In organizing the various aspects involved in the systems approach to the problem of designing equipment, this book logically combines the new set of tools, new classification of parts, and the team of workers necessary to this approach. At the same time, it provides for the engineer, as a member of the system-design team, a background for his job and describes system-design methods. A selective bibliography and illustrative problems with solutions are included.

TELEVISION RECEIVING EQUIPMENT. By W. T. Cocking. Philosophical Library, 15 E. 40th St., New York 16, N.Y., fourth edition, 1957. 454 pages, 5¾ by 8¾ inches, bound. $15.

Detailed nonmathematical descriptions of equipment for black and white receivers. In this revision, considerably more space has been devoted to electromagnetic deflection, synchronizing, and methods for automatic gain control. Although written from the point of view of British designers, notice is taken of American standards and practices.

TRANSISTOR CIRCUITS AND APPLICATIONS. By J. M. Carroll. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1957. 283 pages, 8½ by 11¼ inches, bound. $7.50. An organized and indexed collection of 106 articles that appeared in *Electronics* from 1950 to 1956. The articles are grouped in eight sections: principles of circuit design; design of transistor amplifiers; transistor oscillators; design of transistor pulse circuits; broadcast and home-entertainment applications; military and communications equipment; computers and servomechanisms; and industrial, scientific, and medical devices.

AUTOMATIC DIGITAL CALCULATORS. By A. D. Booth and K. H. V. Booth. Academic Press Inc., Publishers, 125 E. 23rd St., New York 10, N.Y., second edition, 1956. 261 pages, 5¼ by 8¼ inches, bound. $60. An introduction to the theory, design, construction, and use of digital calculators, intended for engineers new to the field. The book has been devised to include information on automatic coding procedures and on new circuit elements such as the transistor and the ferroelectric matrix store. The bibliography is more than twice as long as that in the first edition.

ELEKTRONISCHE RECHENMASCHINEN UND INFORMATIONSVERARBEITUNG. Nachrichtentechnische Fachberichte, Band 4. Friedrich Vieweg & Sohn, Braunschweig, Germany, 1956. 229 pages, 8¼ by 11¾ inches, paper. DM 26. A compilation of more than 60 conference papers on electronic digital computing and information processing, of which one fourth are in English, the rest mainly in German with brief English abstracts. The major sections are divided as follows: generalized topics; development of various actual computers; machine elements, switching circuits, and memory units; programming; numerical processes, with illustrative examples; special cases; and switching theory. The authors represent a wide range of subject backgrounds although all are concerned directly with computers.

GAS CHROMATOGRAPHY. By A. I. M. Keulemans. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N.Y., 1957. 217 pages, 6 by 9¼ inches, bound. $7.50. The practical and theoretical aspects of a relatively new type of analysis especially useful in the petroleum and hydrocarbon industries are covered in this concise manual. The methods, said to be quicker than methods such as mass spectrometry, may be applied in various industries including the manufacture of oils, paints, plastics, rubber goods, food products, and chemicals.

MAINTENANCE ENGINEERING HANDBOOK. Edited by L. C. Morrow. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1957. Various pagings, 6 by 9¼ inches, bound. $20. This comprehensive handbook, containing contributions by more than 80 men, devotes about a third to the management aspects of maintenance, i.e., organization and administration of maintenance forces, personnel, planning and scheduling, project control, and costs and budgets for maintenance operations. The remaining two thirds of the book covers the selection, installation, and upkeep of buildings; electrical, mechanical, service, and transportation equipment; maintenance stores and their control; lubricants and lubrication; instruments; sanitation; welding; and corrosion. Units of production equipment described include bearings, clutches, chains, drives, gears, valves, etc.

MANUFACTURING ORGANIZATION AND MANAGEMENT. By H. T. Amrine, J. A. Ritchey, and O. S. Hulley. Prentice-Hall, Inc., Englewood Cliffs, N.J., 1957. 454 pages, 6 by 9¼ inches, bound. $6.75. Presents in a nontechnical way for the inexperienced person, information on principles and functions of manufacturing management. Although it emphasizes functions usually controlled by the manager, there is also material on marketing, financing, and personnel. Some aspects deal with plant location and layout, design of manufacturing processes, motion and time study, material handling, purchasing, industrial relations, and quality control.

NATIONAL ELECTRONICS CONFERENCE PROCEEDINGS, 1956. Published 1957 by the National Electronics Conference, Inc., 84 E. Raidolph St., Chicago 1, Ill. 1095 pages, 6 by 9¼ inches, bound. $5. Considerably enlarged over previous years, these proceedings contain 119 papers on a wide range of topics: instrumentation, servomechanisms, measurements, data storage, information theory, solid-state devices, microwaves, automation, pulse techniques, etc. Preceding the technical papers are three general papers on the space satellite program, the Midwestern University Research Association, and scientific manpower in the U.S.S.R.

THE PHYSICS OF ELECTRICAL CONTACTS. By F. L. Jones. Oxford University Press, 114 Fifth Ave., New York 11, N.Y., 1957. 219 pages, 5½ by 8¾ inches, bound. $5.60. This book gives the basic physics and properties of contacts without regard to particular designs It contains accounts of recent work and researches in progress on the mechanism of fine transfer, stability and shapes of molten metal bridges, properties of metals at high temperatures, erosion and transfer, discharge phenomena, and surface film phenomena. There is a bibliography of 111 references.

PROCEDURE HANDBOOK OF ARC WELDING DESIGN AND PRACTICE. Published by The Lincoln Electric Company, Cleveland 17, Ohio, 11th Edition, 1957. Various paging, 5⅝ by 9 inches, bound. $3. Provides useful information on all phases of arc welding for the machine designer, the structural engineer, the fabricator, the welder, and all those interested in metal joining. The eight sections cover: history, nomenclature and processes, weldability, mild steel procedures, manufacturing cost data, machine design, structural design, applications, and reference data. The structural section has been completely rewritten and includes the latest data on welded design. The weldability section includes information on welding such new materials as zirconium and titanium.

PROGRESS IN LOW TEMPERATURE PHYSICS, VOLUME II. Edited by C. J. Gorter. North Holland Publishing Company, Amsterdam, Netherlands; Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N.Y., 1957. 480 pages, 6¼ by 9¼ inches, bound. $10.75. Fourteen substantial review papers with extensive lists of references summarize the present state of low temperature research, particularly with reference to magnetism, superconductivity, and liquid helium, but with some attention to other subjects such as various nonmagnetic properties of solids. Some review topics are: helium films, electron transport phenomena in metals, semiconductors at low temperatures, paramagnetic relaxation, and physical properties of rare earth metals.

AIR CONDITIONING. By W. R. Woolrich and W. R. Woolrich, Jr. The Ronald Press Company, 15 E. 26 St., New York 10, N.Y., 1957. 384 pages, 6⅛ by 9⅜ inches, bound. $7.50. Part I of this text is devoted to the general thermodynamics of air conditioning and problems of system load determination and design. Part II covers the elements of heating systems from a discussion of fuels and combustion to a coverage of heat transfer elements such as boilers, radiators and convectors. Part III provides an exposition of the types of refrigeration, including cooling by iced air and evaporation. Part IV deals with five areas: piping design, air distribution, automatic control and instrumentation, sound control, and air contaminant control. The authors have devoted more space than usual to psychrometric processes, radiant cooling, and available means of refrigeration.

ATOMKRAFT: DER BAU VON ATOMKRAFTWERKEN UND SEINE PROBLEME. By Friedrich Münzinger. Springer-Verlag, Berlin, Germany, second edition, 1957. 224 pages, 6¼ by 9⅜ inches, bound. DM 29.40. An introduction to the problems involved in the construction of nuclear power plants. Intended for engineers, industrialists, and power economists, the three main sections deal with: (1) theoretical fundamentals of nuclear energy; (2) reactor technology, including heat engines; and (3) economic aspects of nuclear plants as power producers.

DIGITAL CALCULATING MACHINES. By G. A. Montgomerie. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N.J., 1956. 262 pages, 5¾ by 8⅞ inches, bound. $6.75. A manual for engineers and scientists who want to make effective use of these machines in their work. Four groups of machines are covered: desk-type calculators, punched card systems, special-purpose machines for extensive mathematical operations, and universal sequence controlled machines. Numerous illustrations and examples of operations of the machine are included.

DIGITAL COMPUTER PROGRAMMING. By D. D. McCracken. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1957. 253 pages, 5⅞ by 9¼ inches, bound. $7.75. A general introduction to the entire field intended for engineers and others who want to know how to prepare detailed instructions for the stored program computer. Emphasizing basic principles, the book discusses coding, binary and octal number systems, input–output methods, magnetic tape programming, automatic coding, and other aspects of programming. The discussion is illustrated by detailed examples written for a mythical computer representing major trends in present computer building.

ELECTRICITY AND MAGNETISM. By B. I. Bleaney and B. Bleaney. Oxford University Press, 114 Fifth Ave., New York 11, N.Y., 1957. 676 pages, 6 by 9½ inches, bound. $10.10. This text gives an up-to-date account of the principles and experimental aspects of electricity and magnetism, together with an elementary account of the underlying atomic theory. The four main sections are: (1) electrostatics, electric currents and magnetic fields, magnetostatics, and magnetic effects; (2) alternating current theory and electromagnetic waves, including filters, lines and waveguides; (3) electromagnetic machinery, thermionic vacuum tubes and noise; (4) theory of dielectrics and dispersion, the band theory of metals and semiconductors, paramagnetism and ferromagnetism, and a final chapter on nuclear magnetic resonance and recent r-f measurements of the fundamental constants.

ENGINEERING ECONOMICS AND ETHICS FOR PROFESSIONAL ENGINEERS' LICENSE. By J. D. Constance. Published 1957 by John D. Constance, 625 Hudson Terrace, Cliffside Park, N.J. Various pagings, 8½ by 11 inches, paper. $2.50 Brief notes and worked out examples from past state examinations for professional engineer's license. The subject matter includes bond issues, bond valuation, debt amortization, property valuation, depreciation, cost analysis, contracts, specifications, business law, and professional ethics and practice.

A HISTORY OF MECHANICS. By René Dugas. Central Book Company, Inc., 261 Broadway, New York 7, N.Y., 1957. 671 pages, 6 by 9 inches, bound. $15. A translation from the French edition published in 1950. Part I deals with the important men, schools of thought, fields of activities, and developments from the Greeks and Arabs to the 17 Century. The formulation of classical mechanics during the 17th Century is discussed in Part II, with Parts III and IV covering developments during the 18th and 19th Centuries. The last part of the book discusses 20th Century concepts: the relativity theory, quantum mechanics, wave mechanics, and statistical mechanics. The author has exercised sufficient selectivity to provide a logical and coherent treatment within a reasonable scope.

INDUSTRIAL ORGANIZATION AND MANAGEMENT. By R. C. Davis. Harper & Brothers, 49 E.33rd Street, New York 16, N.Y., third edition, 1957. 953 pages, 6 by 9½ inches, bound. $8.25. Intended for industrial executives as well as for students of management, this book emphasizes fundamental objectives, policies, and methods of approach to the solution of business problems. The 31 chapters of the book cover a wide range of subjects including plant location, plant maintenance, product and process planning, marketing, office management, etc. The numerous examples of management practice have been taken from a variety of manufacturing companies.

INSTRUMENT TECHNOLOGY, Volume 3—Telemetering and Automatic Control. By E. B. Jones. Butterworth Scientific Publications, London W.C. 2, England, 1957. 198 pages, 6 by 10

inches, bound, 40s. The present volume in this series deals in a brief section with pneumatic and electrical telemetering systems, and in more detail with the instruments and mechanisms for automatic control of processes. As in previous volumes, basic principles are discussed before the actual instruments, and the instruments are classified according to the physical principle upon which they are based.

MAGNETIC AMPLIFIER CIRCUITS. By W. A. Geyger. McGraw-Hill Book Company, 330 W. 42nd St., New York 36, N.Y., second edition, 1957. 277 pages, 6 by 9¼ inches, bound. $6. This book is a practical exposition of fundamental principles and applications, with special reference to magnetic servo amplifiers. The major part of the contents is a systematic description of the numerous types of circuits, including nonfeedback; single-stage and multistage circuitry utilizing external or internal feedback; and special types using critical regeneration or derivative feedback. Applications in instrumentation, servomechanisms, regulators, and automatic control devices are discussed. This edition has been enlarged to cover high-speed amplifiers, high-performance closed-loop servo systems, and other recent advances.

MICROWAVE PRINCIPLES. By H. J. Reich and others. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N.J., 1957. 427 pages, 6 by 9¼ inches, bound. $8.75. Essentially an abridgement of the authors' "Microwave Theory and Techniques" (1953), this text has been prepared for a senior course in communications and for practicing engineers who want to review the fundamentals of microwave devices. Similar in content to the earlier book but without the mathematical detail, this book covers transmission lines, waveguides, impedance matching, antennas, resonators, magnetrons, traveling wave tubes and the theory and characteristics of amplifiers and oscillators.

NIEDERFREQUENZ UND MITTELFREQUENZMESSTECHNIK FÜR DAS NACHRICHTENGEBIET. By A. Wirk and H. C. Thilo. S. Hirzel Verlag, Stuttgart, Germany, 1956. 234 pages, 6¼ by 9¼ inches, bound. DM 28. A detailed treatment of measuring techniques in the communication field both for low- and medium-frequencies. Although it covers mainly the equipment and methods developed by the Siemens & Halske Aktiengesellschaft, other important developments are dealt with also. The basic circuits and mathematical analysis are fully covered.

NUCLEAR POWER ENGINEERING. By H. C. Schwenk, R. H. Shannon and B. G. A. Skrotzki. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1957. 319 pages, 5⅜ by 8¼ inches, bound. $6.50. An elementary presentation of the basic facts of the physics, design, materials, economics, and operation of nuclear power plants. The material is a revised and augmented reprint of a series of articles published in *Power* starting in July 1954.

NUCLEAR REACTOR PHYSICS. By R. L. Murray. Prentice-Hall, Inc., Englewood Cliffs, N.J., 1957. 317 pages, 6 by 9¼ inches, bound. $10. Prepared for use by the graduate student in science or engineering and the design engineer in the nuclear energy field, this book discusses the physical concepts and calculation methods involved in the analysis of the behavior of an assembly of fissionable material. The principal emphasis is on three major topics: the distributions in energy and space of neutron flux, the determination of the critical amount of fissionable material, and the transient behavior and control of the reactor as a heat source.

OPTICAL METHODS FOR EXAMINING THE FLOW IN HIGH-SPEED WIND TUNNELS. (Agardograph 23) Part 1—Schlieren Methods by D. W. Holder and R. J. North. Part 2—Interferometer Methods by G. P. Wood. Published 1956 by the Advisory Group for Aeronautical Research and Development, Paris 16, France. 148 pages, 8 by 10½ inches, paper. Price not given. This paper is a review of the present state of knowledge on the use of schlieren, direct shadow, and interferometer techniques for visualizing and photographing the flow in high-speed wind tunnels. Emphasis is placed on the most widely used techniques although there is some discussion on methods which are as yet in an early stage of development. Information on suitable light sources and photographic materials is included.

PHYSICS OF NONDESTRUCTIVE TESTING. Supplement No. 6, British Journal of Applied Physics. Published 1957 by The Institute of Physics, London S.W. 1, England. 72 pages, 8 by 10¾ inches, paper. 25s. A collection of 11 papers and 2 panel discussions, published to give engineers and metallurgists an insight into newer methods of nondestructive testing and their uses. The papers deal with such subjects as mechanical testing of nonmetallic materials, X-ray diffraction, nuclear magnetic resonance, optical fluorescence, and the ultrasonic pulse method. Two brief symposiums are included, one on optical and surface methods, the other on penetrant methods.

PRAZISIONSMESSUNGEN VON KAPAZITATEN INDUKTIVITATEN UND ZEITKONSTANTEN. Volume 1, by Erich Blechschmidt. Friedrich Vieweg & Sohn, Braunschweig, Germany, second edition, 1956. 166 pages, 5¾ by 8¼ inches, paper. DM 11.80. This small manual is one of a series on precision electrical measurements. It deals with both direct and indirect methods of measuring capacitance, high-frequency capacitance measurements, and the measurement of dielectric losses and dielectric constants. A classified, 20-page bibliography is included. The measurement of inductance is intended as the next part of the series.

PRINCIPLES OF ELECTRIC AND MAGNETIC CIRCUITS. By W. B. Boast. Harper & Brothers, 49 E. 33rd St., New York 16, N.Y., second edition, 1957. 369 pages, 6 by 9½ inches, bound. $5.50. The second editon of this text for an introductory course in electrical engineering has been brought up to date in regard to electric energy sources, including discussion of improvements in solar sources. The chapter on loop-current and node-voltage methods has been expanded considerably and that on network theorems has been extensively reorganized. More than 300 problems are provided.

QUALITY CONTROL AND STATISTICAL METHODS. By E. M. Schrock. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N.Y., second edition, 1957. 246 pages, 6 by 9¼ inches bound. $6.75. Intended for those with little knowledge of the field, this second edition presents the most generally useful modern techniques of quality control and statistical methods as applied to industrial problems of product quality. Subjects covered include the nature and economic objectives of quality, the means of presenting information pertaining to quality, the applications of various types of control charts, the various modifications of control limits, probability distribution and significance of differences, and the nature of acceptance sampling. New material has been included on rapid approximate tests of signfiicance, and analysis of variance.

SEMICONDUCTOR ABSTRACTS, VOLUME 3, 1955. Compiled by Battelle Memorial Institute. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1957. 322 pages 8½ by 11¼ inches, bound. $10. Continuing this important and useful series, the present compilation contains over 1,250 abstracts on the properties and applications of semiconducting and luminescent materials. References are grouped under each material and a separate section on general theory lists articles on crystal growth; crystal imperfections, band structure, thermal and photo effects, transistors, etc. Subject and author indexes are included.

SOLID-STATE PHYSICS. By A. J. Dekker. Prentice-Hall Inc., Englewood Cliffs, N.J., 1957. 540 pages, 6 by 9¼ inches, bound. $9. Chapters one to eight of this book deal with topics that can be discussed without reference to the electron theory of solids: the crystalline state, specific heat, lattices, dielectric and optical properties, ionic conductivity, and ferroelectrics. The remaining 19 chapters deal with the electronic properties of solids: free electron theory of metals, band theory, conductivity of metals, luminescense, secondary electron emission, magnetic relaxation, etc. Five appendixes give essential data on thermodynamics, wave mechanics, and quantum statistics. The book is suitable for use as a text or for self-study by engineers new to the field.

VDE FACHBERICHTE, VOLUME 19, 1956. Published 1956 by VDE-Verlag GMBH, Berlin, Germany. Various pagings, 8¼ by 11⅜ inches, paper. DM 30. A compilation of 71 papers presented at the 1956 VDE General Meeting. Part I includes papers on theoretical electrical electrical engineering and measurements, electric power transmission, construction of electrical machinery, insulation, control engineering, and drives. Part II covers theory of signals, telephone exchange engineering, wide-band radio direction finding, specialized problems in radio engineering, miniaturization and its elements. Part III, which consists of only seven papers is on remote control.

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TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

PROCEEDINGS OF THE 1957 ELECTRONIC COMPONENTS SYMPOSIUM. The proceedings now can be ordered for $5 per copy from the symposium office at 84 E. Randolph St., Chicago 1, Ill. The proceedings include 43 technical papers reporting the latest developments in electronic components, as presented at a symposium. The papers deal with nuclear and environmental studies; high temperature investigations and development; instrumentation and measurements; materials; components; and present and future problems and needs. Only a limited number of proceedings are being printed, according to Dr. R. M. Soria, symposium chairman.

INTERNATIONAL GUIDE TO EUROPEAN SOURCES OF TECHNICAL INFORMATION. The International Guide is an up-to-date publication listing sources in 11 countries—Austria, Belgium, Denmark, France, West Germany, Greece, Italy, The Netherlands, Norway, Sweden, and United Kingdom. It will be will be invaluable to all those engaged in applied research, industry, documentation, and library work, and will enable them to locate quickly the most competent sources of technical information. The Guide contains 330 selected sources of technical information in nearly all fields of research and technology: chemistry, physics, metallurgy, engineering, building, textiles, leather, plastics, timber, and many others. A subject and keyword index, as well as an alphabetical list of all sources mentioned complete the Guide. 386 pages, $2.50, from Organization for European Economic Cooperation (OEEC) Mission, Publication Office, 2000 P St., N.W., Washington 6, D.C.

SYMPOSIUM ON SOLDER. (ASTM Special Technical Publication *189*) 190 Pages, $3. Soldering is one metallurgical operation that probably is better known and practiced by more people than any other. However, the simplicity and ease of applying soft solder can be very misleading, for the problems of soldering actually involve several branches of science including chemistry, physics, and metallurgy. The 16 papers comprising this symposium explore these fields in detail. The vital role of fluxes, solder compositions, and applications in attaining satisfactory service performance of soldered joints are illustrated. The manual, mechanized, and ultrasonic techniques of soldering are covered, and, at the same time, the role of standardization in solder technology is emphasized. A unique system is presented for evaluating fluxes, solder alloys, and solderability in numerical terms. The symposium was sponsored by the American Society for Testing Materials (ASTM) Committee *B-2* on Nonferrous Metals and Alloys. Copies may be obtained from

the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

1957 DIRECTORY OF GERMAN MACHINERY AND EQUIPMENT MANUFACTURERS. The Association of German Machinery Manufacturers, Frankfurt, West Germany, has announced publication of the 1957 Directory. This 800-page English-language directory features complete listings of 20,000 manufacturers of all types of machinery, precision instruments, and industrial equipment; classified in 9,000 product categories. The directory is available at $3.50 from the Nordeman Publishing Company, Inc., 14 E. 62nd St., New York 21, N. Y.

ENGINEERS EMPLOYED BY PRIVATE PRACTITIONERS. A nation-wide survey report of the status of engineers employed by consulting firms has just been published by the National Society of Professional Engineers (NSPE). The 40-page report contains basic information on salaries, hours, geographic distribution of engineer employees, size of the consulting firms, fringe benefits, length of the work week, and overtime pay practices. Based on data from questionnaires returned by consulting firms, the survey was a research project undertaken by the Engineers-in-Employ-of-Private-Practitioners Subcommittee of NSPE's Employment Practices Committee. Publication of the report is the first step in a long-range program of obtaining basic facts about the composition and status of engineers employed by consulting firms. The next step will be an analysis of the findings and the development of programs to meet the needs of the engineering employees in their professional and economic advancement. The consulting firms surveyed ranged in size from those employing one engineer to those which employ as many as 300. The questionnaires returned represent data for a total of 6,407 engineers—all employees of consulting firms, as distinct from owners and partners. Median salaries summarized in the report are based on the eight grades of NSPE's "Recommended Grades, Duties, Responsibilities and Qualifications for Pre-Professional and Professional Positions." The median monthly salaries for the eight grades are reported as: $358, $433.55, $504.40, $582.12, $657.70, $768.89, $947.02, and $987.54. These figures do not include payment of bonuses; a common practice in consulting firms. The most popular fringe benefits listed in the report are paid vacations, bonuses, hospitalization insurance, life insurance, and profit-sharing. The standard work week of most of the consulting firms is reported as 40 hours, but 5.8% stated they work less than 40 hours, and 28% reported a work week of 41 to 44 hours. Copies of the survey report may be obtained for $1 each from the National Society of Professional Engineers, 2029 K St., N.W., Washington 6, D.C.

RETMA STANDARDS. The Radio-Electronics-Television Manufacturers Association (RETMA) Engineering Department announced the availability of three new recommended standards for the electronics industry. The standards were published following approval by representatives of the electronics industry, including members and nonmembers of RETMA. Copies are available to all segments of the industry and recently were distributed to representatives of all RETMA member-companies. Nonmembers of the Association may obtain copies of the following new standards through the RETMA Engineering Department, 11 W. 42nd St., New York 36, N.Y. (a minimum charge of $1 is made on all orders): RS-180—Power Transformers for Electronic Equipment (this Standard, from Standards Proposal *No. 510*, is a revision of *TR-102-B*) 50¢; RS-184—Drive Pulleys (this Standard, from Standards Proposal *No. 527*, is a revision of *REC-102-A*) 25¢; RS-186—Standard Test Methods for Electronic Equipment (this Standard, from Standard Proposal *Nos. 467* and *497*, is new material) $1.10.

AUTOMATIC CODING. A collection of the papers given at the Automatic Coding Symposium held recently at The Franklin Institute in Philadelphia, Pa. Included in the monograph are: "Introductory Remarks," J. S. Burlew; "Automatic Coding at GE," R. M. Petersen; "Systems of Debugging Automatic Coding," Charles Katz; "PRINT I—An Automatic Coding System for the IBM *705*," R. W. Bemer; "The Procedure Translator—A System of Automatic Programming," H. M. Kinzler and P. M. Moskowitz; "OMNICODE—A Common Language Programming System," R. C. McGee; "A Matrix Compiler for Univac," L. C. McGinn; "A Mathematical Language Compiler," A. J. Perlis and J. W. Smith; and "A Mechanized Approach to Automatic Coding," E. C. Yowell. Copies of the book may be obtained by sending $3 per copy to AUTO CODE, Franklin Institute, Philadelphia 3, Pa.

STANDARD SAMPLES AND REFERENCE STANDARD. Issued by the National Bureau of Standards (NBS), Circular 552 (second edition), 24 pages, 25¢. Order from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. The Circular is also available without charge to prospective purchasers of Standard Samples, upon request to the NBS. This circular contains an up-to-date descriptive listing of the various Standard Samples issued by the NBS and supersedes Circular 552 issued in August 1954. A schedule of weights and fees, as well as direction for ordering, is included. Summarized tables of analyses are presented to indicate the type of standards of composition presently available. The current status of the various standards will be indicated by a mimeographed insert. The NBS program on standard samples has been in existence almost since the organization of the Bureau. The first standards were prepared in 1905 and, today, over 500 different standard samples of chemicals, ores, ceramics, and metals are prepared, certified, and distributed by NBS. They are used in industrial and research laboratories to control manufacturing processes as well as in evaluating the accuracy of apparatus and equipment. The standard samples are materials that have been carefully analyzed, or whose physical properties have been precisely determined, at the Bureau and other laboratories. Foreign remittances must be in U. S. exchange and should include an additional 25% of the publication price to cover mailing costs.

PROCEEDINGS OF CONFERENCE ON ENGINEERING EDUCATION AND NUCLEAR ENERGY. The United States Atomic Energy Commission (AEC) has issued a 200-page proceedings of a conference on engineering education and nuclear energy, held September 1956 in Gatlinburg, Tenn. Presented by the AEC, the Oak Ridge Institute of Nuclear Studies (ORINS), Oak Ridge National Laboratory, and the American Society for Engineering Education, the conference included papers by leading educators, industrial administrators, and Government officials, including AEC Commissioner W. F. Libby. The proceedings include transcripts of the papers by the 29 speakers, and a list of conference participants. Dr. W. W. Grigorieff, chairman of the University Relations Division of the ORINS, is editor of the volume, *TID-7527*, which is now on sale for $1 by the Office of Technical Services, Department of Commerce, Washington 25, D.C.

DESIGN OF MINIMUM WEIGHT MAGNETIC CORES. A method of calculation useful wherever weight is a factor in the design of magnetic amplifier components has been devised at the Naval Research Laboratory. The method is described in a technical report released for industry use through the Office of Technical Services (OTS), U. S. Department of Commerce. The method enables calculation of the configuration of the magnetic core, case and coil yielding minimum weight for a given volt-second capacity of a magnetic core and coil. The analysis is very general and takes into account limiting quantities such as winding resistances and magnetizing currents. It can be extended to include weights of other related components such as the associated batteries merely by the addition of the appropriate terms to the total weight equation. The report, *PB 121776*, J. W. Kallander, Naval Research Laboratory, January 1957, may be ordered from OTS, U. S. Department of Commerce, Washington 25, D.C. It contains 8 pages, price 50¢.

PROCEEDINGS OF THE 1957 NATIONAL INDUSTRIAL RESEARCH CONFERENCE. The proceedings of this conference now can be ordered at $6 a copy from Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill. The proceedings include 12 papers on management-level decisions on research and development which were presented by top executives at the conference April 24-25, 1957, in Chicago. The papers deal with sales growth through research, more research for the dollar, and extra dividends from research. Copies may be ordered from: Mrs. Alice Jones, NIRC-H, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill. Orders must be accompanied by payment.

THE INDUSTRIAL CHEMISTRY, PROPERTIES, AND APPLICATION OF SILICONES. This is the Edgar Marburg Lecture presented at the 1956 Annual Meeting of the American Society for Testing Materials (ASTE) by Dr. C. E. Reed, general manager of the silicone products department, General Electric Company, Waterford, N. Y. Copies may be obtained from ASTE, 1916 Race St., Philadelphia, Pa., at $1.50 each.

THE 1957 ISOTOPE INDEX. Published by Scientific Equipment Co., 23 N. Hawthorne Lane, Indianapolis 19, Ind., the Index reports that the supply of isotope labeled compounds has increased 30% during the past year. Widely used in industry, research, agriculture, and medicine, isotopes and isotope labeled compounds are now available from 53 suppliers principally in the United States, Canada, and Great Britain. Recent changes in the Atomic Energy Commission regulations now make it possible to purchase many isotopes and labeled compounds in suitable quantities without a license or Government approval. The 100-page Isotope Index includes data on all of the commercially available isotopes from suppliers all over the world. Available at $3 per copy.

RECEIVING TUBE SUBSTITUTION GUIDEBOOK. Easy-to-follow instruction book tells which American receiver tubes can be substituted for European tubes in imported sets. John F. Rider Publisher, Inc., 116 W. 14th St., New York 11, N. Y., has just published the third supplement to the Receiving Tube Substitution Guidebook by H. A. Middleton ($1.35) which contains more than 200 European to American tube substitutions and over 230 American to European tube substitutions. The book also instructs in the necessary wiring changes. In view of the influx of foreign make radio receivers, service technicians will find this portion of the book extremely valuable. This volume also provides 830 receiving tube and over 200 picture tube substitutions as well. The arrangement of material is such that in practical working conditions this book, and the previous ones, are actually a servicing tool instead of a simple book. A cumulative index at the end of this third supplement further supports the claim that these four volumes are service aids. Those technicians who have all four books will be able to locate the tube and make the substitution "in a jiffy."

ASTE COLLECTED TECHNICAL PAPERS. Availability of the Silver Anniversary Edition of their annual Collected Technical Papers has been announced by the American Society of Tool Engineers (ASTE). This library edition of the 1957 Collected Papers presents in a leatherette-bound volume: 45 separate papers, including the first Eli Whitney Memorial Lecture by Louis Polk, and two complete Symposia, embracing 12 papers each, on Ceramic Tooling and Plastic Tooling. These papers were presented at the recent Silver Anniversary Convention of the ASTE in Houston, Texas. This extensive volume covers diverse discussions, ranging from the most recent and complete coverage available today on ceramic and plastic tooling to the engineering behind an earth satelite launching. Also covered are revolutionary processes in rolling techniques, recent tool design advances, the conception and development of JIC Standards and an analysis of the management-tool engineer team. The Ceramic Tool symposium, cosponsored by ASTE, Massachusetts Institute of Technology, Ohio State University, and Warner-Swasey Co., includes a complete review of published Soviet work—where economic and strategic use of recently developed tool materials have given the U.S.S.R. a vanguard position of at least four years. The Plastic Tooling Symposium presents practical data on four popular types of plastic materials and a comparison of the physical properties now available in plastics. This symposium was cosponsored by ASTE and the Society of the Plastics Industry. Write: ASTE Technical Papers, 10700 Puritan Ave., Detroit 38, Mich. ASTE Members $5; Nonmembers $10.

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(Terms expire July 31, 1959)
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Frank E. Canavaciol (1962)* Brooklyn, N. Y.

American Association for the Advancement of Science, Council

E. C. Easton (1958) New Brunswick, N. J.
I. Melville Stein (1958) Philadelphia, Pa.

American Standards Association, Standards Council

W. A. Lewis (1960) Chicago, Ill.
J. R. North (1958) Jackson, Mich.
E. B. Paxton (1959) Schenectady, N. Y.

Alternates

R. C. Bergvall (1958) Pittsburgh, Pa.
J. P. Jordan (1958) Syracuse, N. Y.
A. C. Muir (1958) Philadelphia, Pa.

AEC Advisory Committee on Industrial Information

L. R. Gaty (1958) Philadelphia, Pa.

AIEE-IRE Co-ordination Committee

W. J. Barrett (1958) Newark, N. J.
M. S. Coover (1958) Ames, Iowa
L. F. Hickernell (1958) Hastings-on-Hudson, N.Y.

Conference of Representatives from Engineering Societies of Western Europe and USA (EUSEC)

W. J. Barrett (1958) Newark, N. J.
N. S. Hibshman (1958) New York, N. Y.

Construction Industry Advisory Council

R. W. Wilbraham (1958) Philadelphia, Pa.

Engineering Foundation Board, UET

E. I. Green (1960) New York, N. Y.
R. J. Wiseman (1959) Passaic, N. J.

Engineering Societies Monographs Committee

Malcolm Farmer (1958) West Chester, Pa.
R. W. Sorensen (1958) Pasadena, Calif.

Engineers' Council for Professional Development

E. A. Walker (1960) University Park, Pa.

*Year following name indicates when present appointment ends.

W. Scott Hill (1958) Schenectady, N. Y.
M. D. Hooven (1959) Newark, N. J.

Engineers Joint Council

L. F. Hickernell (1960) Hastings-on-Hudson, N. Y.
M. D. Hooven (1959) Newark, N. J.
L. F. Stone (1959) Newark, N. J.
J. C. Strasbourger (1960) Cleveland, Ohio
J. D. Tebo (1959) Whippany, N. J.

Alternates

F. S. Black (1959) New York, N. Y.
E. I. Green (1959) New York, N. Y.
J. P. Neubauer (1959) New York, N. Y.
W. B. Morton (1959) Allentown, Pa.
H. I. Romnes (1959) New York, N. Y.

General Electric Educational Fund Fellowship Committee

Victor Siegfried (1958) Ashton, R. I.

Hoover Medal Board of Award

O. E. Buckley (1961) Maplewood, N. J.
E. W. Engstrom (1963) New York, N. Y.
D. D. Ewing (1959) Lafayette, Ind.

John Fritz Medal Board of Award

M. S. Coover (1961) Ames, Iowa
M. D. Hooven (1960) Newark, N. J.
A. C. Monteith (1959) Pittsburgh, Pa.
Elgin B. Robertson (1958) Dallas, Texas

Alternates

Hendley Blackmon (1960) Pittsburgh, Pa.

Erich Hausmann (1958) Brooklyn, N. Y.
E. C. Molina (1961) East Orange, N. J.
C. F. Savage (1959) New York, N. Y.

Kettering Board of Award

M. D. Hooven (1958) Newark, N. J.
B. G. A. Skrotzki (1960) New York, N. Y.

Library Board, United Engineering Trustees, Inc.

W. G. Vieth (1959) New York, N. Y.
R. T. Weil, Jr. (1961) New York, N. Y.

Marston Medal Board of Award

R. B. Gear (1960) Chicago, Ill.

National Association of Corrosion Engineers Inter-Society Committee on Corrosion

Ray M. Wainwright, Senior Delegate (1958) Ogallala, Nebr.
Hugo W. Wahlquist (1958) New York, N. Y.

National Bureau of Engineering Registration, Advisory Board

F. H. Knapp (1958) Cleveland, Ohio

National Bureau of Standards, Advisory Committee

Ralph Bown (1959) Maplewood, N. J.
H. P. Corwith (1960) New York, N. Y.
J. A. Hutcheson (1959) East Pittsburgh, Pa.
W. A. Lewis (1960) Chicago, Ill.
R. C. Sprague (1958) North Adams, Mass.
C. G. Suits (1958) Schenectady, N. Y.

National Electronics Conference, Board of Directors

Roger R. Jenness (1957) Evanston, Ill.

National Fire Waste Council

R. L. Lloyd (1958) Washington, D. C.
H. H. Watson (1958) Bridgeport, Conn.

National Research Council, Division of Engineering and Industrial Research

J. E. Hobson (1959) Boston, Mass.

Sperry Medal Board of Award

Edward H. Anson (1959) New York, N. Y.
William N. Zippler (1961) New York, N. Y.

United Engineering Trustees

W. J. Barrett (1959) Newark, N. J.
J. F. Fairman (1960) New York, N. Y.
C. H. Linder (1961) New York, N. Y.

U. S. National Committee of the International Commission on Illumination

R. D. Churchill (1958) Cleveland, Ohio
R. C. Putnam (1958) Cleveland, Ohio
D. W. Rowten (1958) Cleveland, Ohio

Washington Award Commission

Bernard N. Gussett (1958) Des Moines, Iowa
Raymond D. Maxson (1959) Chicago, Ill.

World Power Conference

E. I. Pollard (1958) Ridgway, Pa.
F. L. Lawton, *Alternate* (1958) Montreal, Que., Canada

Geographical District Executive Committees

District	Chairman (Vice-President, AIEE)	Secretary (District Secretary)	Chairman, District Committees on Student Activities
1 Empire	D. E. Garr, General Electric Company, 3-112, Electronics Park, Syracuse, N. Y.	Lynn C. Holmes, Stromberg-Carlson Company, 100 Carlson Rd., Rochester 3, N.Y.	Ralph Gentile, Dept. of Electrical Engineering, Clarkson College of Technology, Potsdam, N. Y.
2 Middle Eastern	B. R. Teare, Jr., Dept. of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.	Edward R. Schatz, College of Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.	Finley W. Smith, Dept. of Electrical Engineering, Lafayette College, Easton, Pa.
3 Metropolitan New York	L. F. Stone, General Electric Company, 744 Broad St., Newark 2, N. J.	J. R. Kerner, Westinghouse Electric Corporation, 40 Wall St., New York, N. Y.	J. R. Rankin, Electrical Engineering Department, Rutgers University, New Brunswick, N. J.
4 Southern	H. W. Oetinger, Duke Power Company, Charlotte 1, N. C.	B. V. Martin, Westinghouse Electric Corporation, Box 1399, Charlotte 1, N. C.	H. A. Owen, Electrical Engineering Department, Duke University, Durham, N. C.
5 Great Lakes	J. H. Foote, Commonwealth Associates, Inc., 209 E. Washington Ave., Jackson, Mich.	L. W. Clark, Detroit Edison Company, 2000-2nd Ave., Detroit 26, Mich.	John D. Dixon, Dept. of Electrical Engineering, University of North Dakota, Grand Forks, N. D.
6 North Central	A. G. Johnson, Omaha Public Power District, Electric Bldg., Omaha, Nebr.	C. S. Roadhouse, Omaha Public Power District, Omaha, Nebr.	George E. Gless, Jr., Dept. of Electrical Engineering, University of Colorado, Boulder, Colo.
7 South West	N. F. Rode, Dept. of Electrical Engineering, A&M College of Texas, College Station, Tex.	Walter E. Silvus, General Electric Company, 1312 Live Oak St., Houston 1, Texas	R. R. Krezdorn, Dept. of Electrical Engineering, University of Texas, Austin 12, Texas
8 Pacific	O. A. Gustafson, General Electric Company, 235 Montgomery St., San Francisco, Calif.	Clive E. Baugh, Pacific Gas & Electric Company, 245 Market St., San Francisco, 6, Calif.	James L. Knickerbocker, Dept. of Electrical Engineering, University of Arizona, Tucson, Ariz.
9 North West	M. M. Ewell, Westinghouse Electric Corporation, 309 S.W. 6th Ave., Portland 4, Oreg.	Howard Arnett, Portland General Electric Company, 621 S.W. Alder St., Portland 5, Oreg.	R. E. Stephenson, Dept. of Electrical Engineering, University of Utah, Salt Lake City, Utah
10 Canada	G. F. Tracy, University of Toronto, Electrical Bldg., Toronto, Ont., Canada	D. N. Culver, Bell Telephone Company, 393 University Ave., Toronto, Ont., Canada	Maurice Boisvert, Dept. of Electrical Engineering, Laval University, Quebec, Que., Canada
11 East Central	H. H. Kerr, Toledo Edison Company, Edison Bldg., Toledo, Ohio	Norman L. Danforth, Allis-Chalmers Manufacturing Company, 1703 Toledo Trust Bldg., 245 Summit Street, Toledo, Ohio	R. W. Schindler, Dept. of Electrical Engineering, Fenn College, Cleveland, Ohio.
12 North Eastern	S. M. Osthagen, Allis-Chalmers Manufacturing Company, 240 Olney St., Providence 6, R. I.	J. W. Bennett, Western Massachusetts Electric Company, 73 State St., Springfield, Mass.	Philip Seal, Dept. of Electrical Engineering, Norwich University, Northfield, Vt.

NOTE: Each District executive committee includes also the chairmen and secretaries of all Sections within the Districts, the District vice-chairman of the AIEE Membership Committee, a member of the Sections Committee who is a resident in the District, and a representative of the Technical Operations Department who is a resident in the District.

Sections

Name	District	When Organized	Chairman	Secretary	Secretary's Address
Akron	11	Aug. 12, '20	R. J. Feeney	D. C. Emery	2053 14th St., Cuyahoga Falls, Ohio
Alabama	4	May 22, '29	S. W. Reese	G. H. Hoffman	Allis-Chalmers Manufacturing Company, Brown-Marx Bldg., Birmingham, Ala.
Arizona	8	Mar. 22, '41	W. E. MacMorran	F. M. Irish	505 West Lewis, Phoenix, Ariz.
Arkansas	7	Apr. 23, '47	H. J. Owen		
Arrowhead	5	Apr. 23, '47	J. E. Abramson	Melvin G. Alderink	317 Kenilworth Ave., Duluth 3, Minn.
Baton Rouge	4	Feb. 3, '55	M. B. Reed	E. R. Felton	2230 Ebony Ave., Baton Rouge, La.
Beaumont	7	June 27, '45	John Moriaty	E. A. Baumgartner	3850 W. Lynwood Dr., Beaumont, Texas
Boston	12	Feb. 13, '03	H. W. Evirs, Jr.	W. F. Burt	NEGEA Service Corp., 10 Temple St., Cambridge 39, Mass.
Canton	11	Nov. 4, '47	D. E. Himes	J. E. Hamman	1505 27th St., N.W., Canton, Ohio
Central Illinois	5	June 28, '51	J. W. Marquardt	H. W. Griffith	Sangamo Electric Company, Springfield, Ill.
Central Indiana	5	Jan. 12, '12	J. B. Wark	L. V. Leonard	901 N. Campbell Ave., Indianapolis, Ind.
Chicago	5	1893		E. G. Norell	
Cincinnati	11	June 30, '20	W. A. Farris	A. C. Stewart	The Cincinnati Gas & Electric Company, P. O. Box 960, Cincinnati 1, Ohio
Cleveland	11	Sept. 27, '07	K. L. Wheeler	J. Bronaugh	Allis-Chalmers Manufacturing Company, 1905 N.B.C. Bldg., Cleveland 14, Ohio
Columbus	11	Mar. 17, '22	F. C. Weimer	E. O. Wolden	Columbus & Southern Ohio Electric Co., 215 N. Front St., Columbus 15, Ohio
Connecticut	12	Apr. 16, '21			
Corpus Christi	7	Oct. 25, '51	Floyd A. Salmon	J. D. deSilva	1209 Roy Dr., Corpus Christi, Texas
Dayton	11	June 9, '43	W. R. Jacox	G. B. Schrank	4026 Middlehurst Lane, Dayton 6, Ohio
Delaware Bay	2	June 1, '52	C. G. Tarkenton	B. J. Taylor	Box 100—Rd. 1, Newark, Del.
Denver	6	May 18, '15	Orval P. Settles	J. E. Martin	Public Service Company of Colorado, Denver 2, Colo.
East Tennessee	4	Sept. 2, '36	M. Stephens Merritt	James C. Barker	1737 Ganasita Trail, Chattanooga, Tenn.
El Paso	7	Mar. 7, '40	Frank E. Gray	H. A. Wilson	El Paso Electric Company, P. O. Box 982, El Paso, Texas
Erie	2	Jan. 11, '18	J. F. Davis	J. J. Grumblatt	20 E. 10th St., Erie, Pa.
Fort Wayne	5	Aug. 14, '08	Charles R. Johnson	D. B. Searls	Westinghouse Electric Corporation, 128 W. Washington, Fort Wayne, Ind.
Gem State	9	Apr. 5, '57	Paul W. Worthen	W. Bruce Mitchell	Route 2, Parma, Idaho
Georgia	4	Jan. 14, '04	J. F. Willett	J. L. Bodeker	Georgia Public Service Comm., 244 Washington St., S.W. Atlanta, Ga.
Hamilton	10	May 1, '53	R. A. Briggs	C. F. B. Dover	Steel Company of Canada, Ltd., Wilcox St., (Elec. Dept.), Hamilton, Ont., Canada
Hawaii	8	June 24, '54	F. B. Martin, Jr.	D. S. Bowman, Jr.	231 Kailua Road, Lanikai, Oahu, T. H.
Houston	7	Aug. 7, '28	Marion T. Robin	Amos F. Williams	Transcontinental Gas Pipeline, P. O. Box 296, Houston, Texas
Illinois Valley	5	June 30, '45	F. A. Ericzon	R. E. Selby	518 W. Carrington Ave., Peoria, Ill.
Iowa	5	June 29, '29	R. C. Ringstrand	P. M. Anderson	Electrical Engineering Dept., Iowa State College, Ames, Iowa
Iowa-Illinois	5	June 24, '54	W. E. Keefe	L. L. Corbin	1628 Lincoln Road, Bettendorf, Iowa
Ithaca	1	Oct. 15, '02	Clyde Fitch	A. O. Kenyon	153 Riverside Drive, Binghamton, N. Y.
Jacksonville	4	Jan. 28, '31	J. M. Wright		
Johnstown	2	Apr. 14, '55	G. T. Evans	R. M. Frank	Pennsylvania Electric Company, 222 Levergood St., Johnstown, Pa.
Kansas City	7	Apr. 14, '16	R. M. Goar	E. L. Mueller	Kansas City Power & Light Company, Kansas City, Mo.
Lehigh Valley	2	Apr. 16, '21	W. F. Dunkle	L. L. Nonemaker	Pennsylvania Power & Light Company, 901 Hamilton St., Allentown, Pa.
Lima	11	June 24, '54	R. E. Klokow	G. H. Stearley	1607 N. West St., Lima, Ohio
Los Angeles	8	May 19, '08	H. A. Lott	Fred Foulon	547 N. Sierra Bonita Ave., Hollywood, Calif.
Louisville	4	Oct. 15, '26	W. B. Watkins	T. D. Caudill	3705 Glenmeade Road, Louisville 5, Kentucky
Lynn	12	Aug. 22, '11	D. M. Longenecker	E. F. Hansen	General Electric Company, 920 Western Ave., Lynn, Mass.
Madison	5	Jan. 8, '09	J. T. Wright	R. H. Balliette	4302 Major Ave., Madison, Wis.
Maine	12	June 30, '55	C. E. Monty	L. W. Burr	Bucksport, Maine
Mansfield	11	Mar. 6, '39	C. C. Crow	C. C. Curran	North Electric Company, Galion, Ohio
Maryland	2	Dec. 16, '04	T. E. Marburger	G. Philip Stout	Aeronca Manufacturing Corporation, Research Division, Hilltop and Frederick Roads, Baltimore 28, Md.
Memphis	4	May 22, '30	R. D. Barrett	L. H. Heyman	P. O. Box 388, Memphis, Tenn.
Mexico	7	June 29, '22	Julio Colon	G. G. Santaella	Gabriel Mancera #1660, Mexico 12, D. F. Mexico
Miami	4	Feb. 3, '49	R. H. Stevens		
Michigan	5	Jan. 13, '11	H. M. Hess	J. W. Eakins	Jesse W. Eakins Co., 16575 Couzens Highway, Detroit 21, Mich.
Milwaukee	5	Feb. 11, '10	R. J. Ungrodt	W. R. Ibach	Wisconsin Electric Power Company, 231 W. Michigan St., Milwaukee 1, Wis.
Minnesota	5	Apr. 7, '02	Seth N. Witts	H. W. Ecker	Minnesota Mining & Manufacturing Company, 900 Bush Ave., St. Paul, Minn.
Mississippi	4	June 28, '51	J. R. Burnie	R. E. Briggs	P. O. Box 943, Jackson, Miss.
Mobile-Pensacola	4	Jan. 22, '53	J. G. Pride	L. E. Grandy	U. S. Engineers, P. O. Box 1169, Mobile 7, Ala.
Montana	9	June 24, '31	Glenn H. Clapp	R. C. Nealey	Allis-Chalmers Manufacturing Company, 81 Hirbour Bldg., Butte, Mont.
Montreal	10	Apr. 16, '43	R. A. Boyd	E. D. Bent	Northern Electric Company, Ltd., P. O. Box 6124, Montreal, Que., Canada
Nashville	4	June 28, '51	H. C. Hartman	R. L. Hutto	2739 Larmon Dr., Nashville 4, Tenn.
Nebraska	6	Jan. 21, '25	W. A. Richardson	P. T. Baird	Consumers Public Pr. Dist., 1401-O St., Lincoln, Nebr.
New Hampshire	12	Sept. 3, '53	S. P. Sawyer	R. A. Nichols	Public Service Company of New Hampshire, 1087 Elm St., Manchester, N. H.
New Orleans	4	Dec. 8, '33	A. J. Lehman	S. G. Dinkel	General Electric Company, 1004 Richards Bldg., New Orleans 12, La.
New York	3	Dec. 10, '19	R. W. Gillette	W. G. Vieth	Western Union Telegraph Company, 60 Hudson St., New York 13, N. Y.
Niagara Frontier	1	Feb. 10, '25	V. A. Leitzke		
Niagara International	10	Aug. 5, '48	W. D. Brown	A. M. Bizzell	1325 2nd Ave., Niagara Falls, Ont., Canada
North Carolina	4	Mar. 21, '29	W. D. Stevenson	C. R. Webster	Westinghouse Electric Corporation, Box 2146, Raleigh, N. C.
Northeastern Michigan	5	Feb. 2, '50	W. A. Stelzer	R. C. Youngdahl	3202 Brentwood Dr., Flint, Mich.
Northern New Mexico	7	Jan. 25, '51	M. C. Heffelman	John M. Havs	Public Service Company of New Mexico, Albuquerque, N. M.
North Texas	7	May 18, '28	John B. Robuck	John L. Sandlin	Priester Supply Co., 1800 Griffin St., Dallas 2, Texas
Oak Ridge	4	Feb., 1950	J. C. Haydon, Jr.	Paul Rubel	222 North Purdue Ave., Oak Ridge, Tenn.
Ohio Valley	11	June 28, '51	F. R. Willoughby	E. D. Purdum, Jr.	3111 Brandon Rd., Huntington, W. Va.
Oklahoma City	7	Feb. 16, '22	C. W. Anthony	H. L. Tredennick	General Electric Company, 1106 Cravens Bldg., Oklahoma 2, Okla.
Ottawa	10	June 23, '49	G. Y. Slader	R. P. Gaylord	490 Golden Ave., Ottawa 3, Ont., Canada
Panhandle Plains	7	June 12, '47	L. L. Davis	S. S. Rutledge	Graybar Electric Company, P. O. Box 2492, Amarillo, Texas
Philadelphia	2	Feb. 18, '03	B. H. Zacherle	Roger S. Hewitt	Brown Instrument Div. of Minnesota, Honeywell Regulator Company, Wayne and Windrim Ave., Philadelphia 44, Pa.

Pittsburgh	2	Oct. 13, '02				
Pittsfield	12	Mar. 25, '04	B. A. Cogbill	W. J. Degnan	General Electric Company, Bldg. 16—Room 210, 100 Woodlawn Ave., Pittsfield, Mass.
Portland	9	May 18, '09	James C. Kirwan	C. C. Diamond	Bonneville Power Administration, P. O. Box 3537, Portland, Oreg.
Providence	12	Mar. 12, '20	L. S. Taber	Anthony L. Marshall	21 Woburn Road, Rumford 16, R. I.
Richland	9	Apr. 23, '48	H. A. Carlberg	A. A. Maxwell	801 Birch, Richland, Wash.
Ridgway	2	June 26, '52	H. T. Hulburt	P. S. Johrde	524 Shaffer Ave., Ridgway, Pa.
Rochester	1	Oct. 9, '14	J. T. Johnson	S. P. Bartles	Eastman Kodak Company, Kodak Park Works, Rochester 4, N. Y.
Rock River Valley	5	Apr. 23, '47	R. E. Ford		
Sacramento	8	June 15, '50	E. C. Sparrow	J. E. Chester	3610 Dayton St., Del Paso Heights, Calif.
St. Louis	7	Jan. 14, '03	R. J. W. Koopman	J. E. Roomy	General Electric Company, 818 Olive St., St. Louis 1, Mo.
St. Maurice Valley	10	June 24, '54	W. G. Seline	G. W. Cook	7 Wayagamack Island, Trois-Rivieres Quebec, Que., Canada
San Diego	8	Jan. 18, '39	L. L. LaZelle	B. B. Shaffer	1045 Tarento Dr., San Diego 7, Calif.
San Francisco	8	Dec. 23, '04	C. F. Dalziel	R. H. Miller	Pacific Gas & Electric Company, 245 Market St., San Francisco 6, Calif.
Savannah	4	Oct. 14, '54			
Schenectady	1	Jan. 26, '03	H. W. Bibber	J. Coleman White	34 St. Stephens Lane, Scotia 2, N. Y.
Seattle	9	Jan. 19, '04	Robert W. Ilman	Glenn Ward-Davis	Seattle City Light, 105 3rd Ave., Seattle 4, Wash.
Sharon	2	Dec. 11, '25	G. J. Hattrup	T. R. Specht	499 Boyd Dr., Sharon, Pa.
Shreveport	7	June 12, '47	J. G. Boyd	A. M. Randolph	3515 Stonewall, Shreveport 51, La.
South Bend	5	Feb. 26, '41	R. C. Emery	D. W. Comstock	Westinghouse Electric Corporation, 216 E. Wayne St., South Bend, Ind.
South Carolina	4	Mar. 2, '40	J. T. Steppe, Jr.		
South Texas	7	May 23, '30	Thomas A. Dodson	E. H. Soderberg	4905 Beverly Hills Dr., Austin, Texas
Spokane	9	Feb. 14, '13	R. D. Brown	W. A. Morgan	The Washington Water Power, P. O. Box 1445, Spokane 10, Wash.
Springfield	12	June 29, '22			
Susquehanna	2	June 18, '53	E. M. Elias	W. W. Middleton	Bell Telephone Company of Pennsylvania, 210 Pine St., Harrisburg, Pa.
Syracuse	1	Aug. 12, '20	W. A. Bangs		
Tampa	4	Feb. 1, '52	P. R. Gibbons		
Toledo	11	June 3, '07	C. E. Campbell	H. E. Kohler	General Electric Company, 420 Madison Ave., Toledo 4, Ohio
Toronto	10	Sept. 30, '03	R. J. Brown	P. D. Smith	Supreme Power Supplies, 2 Audley St., MIMICO, Toronto 14, Ont., Canada
Tulsa	7	Oct. 1, '37	D. M. Allison		
Utah	9	Mar. 9, '17	R. E. Stephenson	F. C. Bates	2018 E. 21st St. South, Salt Lake City 6, Utah
Vancouver	9	Aug. 22, '11	G. J. Henrikson	R. C. A. Stewart	Canadian General Electric Company, 3030 E. Broadway, Vancouver 12, B. C., Canada
Victoria	9	Oct. 5, '56		O. B. Bass	747 Lampson St., Esquimalt, B. C., Canada
Virginia	4	May 19, '22	David J. Ball	Murray S. Spicer	1401 Peachtree Blvd., Richmond, Va.
Virginia Mountain	4	June 23, '49	J. O. Bewley, Jr.	D. M. Morley	General Electric Company, P. O. Box 2488, Roanoke, Va.
Washington	2	Apr. 9, '03	Myron M. Moore	J. R. O'Hanlon	Potomac Electric Power Company, 10th-E-Sts., N.W., Washington, D. C.
West Michigan	5	June 24, '54	Wilbur J. Sundheimer	G. F. Raven	2156 Monroe Ave., N.W., Grand Rapids, Mich.
West Virginia	11	Apr. 9, '40	J. C. Norton	L. M. Roth	319 Ohio Ave., St. Albans, W. Va.
Wichita	7	Sept. 16, '37	Charles S. Clark	J. H. Jenkins	4421 E. Clark St., Wichita, Kans.
Worcester	12	Feb. 18, '20	F. J. Levitsky	W. J. Creighton	General Electric Company, 288 Grove St., Worcester 5, Mass.

Total Sections.....111

Subsections

Name	Chairman	Secretary	Secretary's Address
Adirondack (Schenectady Section)	R. E. Gratton	J. D. Stacy	General Electric Company, Bldg. 8-3A, Hudson Falls, N. Y.
Atlantic City Division (Philadelphia Section)	B. J. Garwood	R. G. Michael, Jr.	117 Ryon Ave., Pleasantville, N. J.
Billings (Montana Section)			
Binghamton Area (Ithaca Section)	D. A. Florance	E. A. Madlon	45 Norman Rd., M. R. 97, Binghamton, N. Y.
Black Hills (Denver Section)			
Blue Ridge (Virginia Section)	Morris W. Jones	R. S. Stewart	914 Baylor St., Staunton, Va.
Boulder City (Los Angeles Section)	W. K. Imhoff	R. E. Bellis	801 New Mexico St., Boulder City, Nev.
Cedar Valley (Iowa Section)			
Central Savannah River (South Carolina Section)			
Central Texas (North Texas Section)	Estil Lawless	Russell J. Sayger	Brazos Electric Power Cooperative, Inc., 2404-12 La Salle Ave., Waco, Texas
Centre County (Pittsburgh Section)			
Charleston (South Carolina Section)			
Charlotte (North Carolina Section)	W. K. Harding	H. C. Byrd	Duke Power Company, Charlotte, N. C.
Chillicothe (Columbus Section)	F. S. Kalisik	Art Wilson	212 Lee Circle, Waverly, Ohio
Columbia (South Carolina Section)	T. O. McKeown, Jr.	B. F. Goldberg	1806 W. Buchanon, Dr., Columbia, S. C.
Eastern Division (St. Louis Section)	Thomas Harmon	Charles L. Eletson	947 Douglas St., Alton, Ill.
Eastern North Carolina (North Carolina Section)	E. G. Manning	S. D. Mauney, Jr.	3231 Oak Grove Circle, Raleigh, N. C.
Eastern Shore (Maryland Section)	R. R. Jefferson	C. Elmer Moore	P. O. Box 187, Seaford, Del.
Eugene (Portland Section)	David M. Hoffman	Donald E. Heym, Jr.	Corps of Engineers, Lookout Point Project, Lowell, Oreg.
Fort Worth (North Texas Section)	Felix Quirino	E. D. Button	General Electric Company, 1407 Electric Building, Fort Worth, Texas
Fox River Valley (Milwaukee Section)	E. F. Wovtych	R. G. Schoemer	131 Orchard Road, Kohler, Wis.
Freeport (Houston Section)	H. W. Swan	G. B. Dorroh	917 Magnolia, Lake Jackson, Texas
Fresno Division (San Francisco Section)	C. L. Smith	D. M. Jensen	Westinghouse Electric Corporation, P. O. Box 391, Fresno 8, Calif.
Guelph (Hamilton Section)	M. K. Schurter	L. J. MacKinnon	Canadian General Electric Company, Guelph, Ont., Canada
Hampton Roads (Virginia Section)	R. B. Helfrich	D. M. Crabtree	105 Wesley Road, Portsmouth, Va.
Helena (Montana Section)			
Hudson Valley Division (New York Section)			
Huntsville (East Tennessee Section)	C. O. Brooks	R. L. Riemer	Chrysler Corporation, Missile Operations, P. O. Box 857, Huntsville, Ala.
Lake Charles (Beaumont Section)			
Lexington (Louisville Section)			
London (Hamilton Section)	R. T. Houlihan	T. E. Smith	M. M. Dillon & Co., London, Ont., Canada
Los Alamos-Santa Fe (Northern New Mexico Section)	J. F. Buchan	E. O. Swickward	P. O. Box 1663, Los Alamos, N. Mex.

Marion (Fort Wayne Section)				
Medford (Portland Section)	L. M. Stinson	R. H. Denyer	19 Ross Court, Medford, Oreg.	
Merrimack Valley (Lynn Section)	F. R. Stansel	P. Chontoian	Research and Advanced Development Div., AVCO Manufacturing Corporation, 20 South Union St., Lawrence, Mass.	
Mid-State (North Carolina Section)	D. H. Mitchell	D. F. Chappell	R. J. Reynolds Tobacco Company, Winston-Salem, N. C.	
Monroe (Shreveport Section)	R. B. Bailey	J. R. McKinley	104 Rochelle Ave., Monroe, La.	
Monterrey (Mexico Section)				
Montgomery (Alabama Section)	Col. W. O. Shrader	M. J. Harris, Jr.	Central Alabama Electric Co-operative, Prattville, Ala.	
Muscle Shoals (East Tennessee Section)	R. L. Townsend			
New Jersey Division (New York Section)	G. H. Needham	P. T. Sproul	11 Aberdeen Road, Chatham, N. J.	
New London (Connecticut Section)				
Northwest Arkansas (Arkansas Section)				
Northwest Iowa (Iowa Section)				
Paducah (Louisville Section)	J. K. Phipps			
Piedmont (South Carolina Section)	A. E. Blair			
Quebec (Montreal Section)				
Racine-Kenosha (Milwaukee Section)	Alvin Welch			
Red River Valley Division (Minnesota Section)	Dean Jacobson, Jr.	Joseph J. Malone	Northwestern Bell Telephone, 105 North 5th St., Fargo, N. Dak.	
Reno (San Francisco Section)	Walter Herz	arl Cooper	Sierra Pacific Power Company, 220 South Virginia St., Reno, Nev.	
Richmond (Virginia Section)	C. W. Parker, Jr.	Allan S. Hadfield	8502 Rivermont Dr., Richmond 26, Va.	
Riverside-San Bernardino (Los Angeles Section)	C. N. Parker	C. L. Westmann	Southern California Edison Company, P. O. Box 69, San Bernardino, Calif.	
St. Lawrence International (Syracuse Section)				
San Jose (San Francisco Section)	D. R. Nelson	J. M. Shulman	Westinghouse Electric Corporation, Sunnyvale, Calif.	
Scioto Valley (Ohio Valley Section)				
Shasta Division (San Francisco Section)	O. J. Horst	Leo Gobel	911 E. St., Orland, Calif.	
Southern Idaho (Gem State Section)				
Tacoma (Seattle Section)	Kenneth Cox			
Tullahoma (East Tennessee Section)	R. J. McGonegle	F. H. Grisard	Technical Services (Electrical) ARO, Inc. AEDC, Tullahoma, Tenn.	
Vermont (Pittsfield Section)	C. W. Hoilman	H. A. VanDine	General Electric Company, Lakeside Ave., Burlington, Vt.	
Wenatchee (Spokane Section)	S. A. Nelson	H. M. Schoffen	Chelan County, P. U. D#1, P. O. Box 1231, Wenatchee, Wash.	
West Central Texas Division (North Texas Section)	R. G. Meador	R. B. Edmundson	1849 N. 8th St., Abilene, Texas	
Western North Carolina (North Carolina Section)	W. J. R. Thomas	J. R. Stevens	Champion Paper & Fiber Company, Canton, N. C.	
Zanesville (Columbus Section)	W. M. Pahel	Hubert Reber	P. O. Box 933, Zanesville, Ohio	

Total Subsections 64

Student Branches

Name and Location	District	Counselor (Member of Faculty)
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Alabama Polytechnic Institute, Auburn, Ala.	4	Albert T. Sprague, Jr.
*Alabama, University of, University, Ala.	4	W. F. Gray
†Alaska, University of, College, Alaska	9	Robert P. Merritt
*Alberta, University of, Edmonton, Alta., Canada	10	R. E. Phillips
*Arizona, University of, Tucson, Ariz.	8	James L. Knickerbocker
*Arkansas, University of, Fayetteville, Ark.	7	Bryan Webb, Jr.
†Bradford Durfee Technical Institute, Fall River, Mass.	12	Bertram Hardy
*British Columbia, Univeristy of, Vancouver, B. C., Canada	9	L. R. Kersey
*Brooklyn, Polytechnic Institute of, Brooklyn, N. Y. (Day)	3	C. W. Lawrence
*Brooklyn, Polytechnic Institute of, Brooklyn, N. Y. (Evening)	3	Frederick G. Van Note
*Brown University, Providence, R. I.	12	E. P. Stabler
*Bucknell University, Lewisburg, Pa.	2	Honer E. Webb
†Buffalo, University of, Buffalo, N. Y.	1	F. P. Fischer
*California Institute of Technology, Passadena, Calif.	8	G. D. McCann
†California State Polytechnic College, San Luis Obispo, Calif.	8	Warren R. Anderson
*California, University of, Berkeley, Calif.	8	Henry C. Bourne, Jr.
*Carnegie Institute of Technology, Pittsburgh, Pa.	2	Paul L. Smith
Case Institute of Technology, Cleveland, Ohio	11	R. D. Chenoweth
Catholic University of America, Washington, D. C.	2	J. C. Michalowicz
†Christian Brothers College, Memphis, Tenn.	4	Lawrence Philip
*Cincinnati, University of, Cincinnati, Ohio	11	W. H. Middendorf
*Clarkson College of Technology, Potsdam, N. Y.	1	Ralph Gentile
*Clemson A & M College, Clemson, S. C.	4	H. V. Poe
*Colorado State University, Fort Collins, Colo.	6	P. H. Lindon
*Colorado, University of, Boulder, Colo.	6	George E. Gless, Jr.
*Columbia University, New York, N. Y.	3	P. Mauzey
*Connecticut, University of, Storrs, Conn.	12	Harold M. Lucal
*Cooper Union, New York, N. Y.	3	
*Cornell University, Ithaca, N. Y.	1	Norman M. Vrana
*Dayton, University of, Dayton, Ohio	11	James N. Yakura
*Delaware, University of, Newark, Del.	2	H. Hellerman
*Denver, University of, Denver, Colo.	6	Arlie E. Paige
*Detroit, University of, Detroit, Mich.	5	Robert W. Ahlquist
*Drexel Institute of Technology, Philadelphia, Pa.	2	F. C. Powell
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*New Hampshire, University of, Durham, N. H.	12	J. B. Murdoch
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*New Mexico, University of, Albuquerque, N. Mex.	7	R. W. Tapy
*New York, College of the City of, New York, N. Y.	3	W. T. Hunt
*New York University, New York, N. Y. (Day)	3	L. J. Hollander
*New York University, New York, N. Y. (Evening)	3	L. J. Hollander
*North Carolina State College, Raleigh, N.C.	4	Edwin W. Winkler
*North Dakota State College, Fargo, N. Dak.	5	R. N. Faiman
*North Dakota, University of, Grand Forks, N. Dak.	5	John D. Dixon
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*Northwestern University, Evanston, Ill.	5	Endrik Noges
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*Ohio State University, Columbus, Ohio	11	E. E. Kimberly
*Ohio University, Athens, Ohio	11	Gustavus Smith
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*Oklahoma, University of, Norman, Okla.	7	Jack Warhurst
Oregon State College, Corvallis, Oreg.	9	L. N. Stone
*Pennsylvania State University, University Park, Pa.	2	R. E. Armington
*Pennsylvania, University of, Philadelphia, Pa.	2	Raymond Berkowitz
Pittsburgh, University of, Pittsburgh, Pa.	2	R. C. Gorham
*Pratt Institute, Brooklyn, N. Y.	3	L. M. Hashmall
*Princeton University, Princeton, N. J.	2	H. M. Chandler, Jr.
Puerto Rico, University of, Mayaguez, P. R.	3	Jose L. G. DeQuevedo
*Purdue University, Lafayette, Ind.	5	Stephen Freeman, Jr.
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*Saint Louis University, St. Louis, Mo.	7	William M. McCabe
*Santa Clara, University of, Santa Clara, Calif.	8	Jack A. Peterson
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*South Dakota State College, Brookings, S. Dak.	5	Maoling Liu

Fenn College, Cleveland, Ohio	11	R. W. Schindler
*Florida, University of, Gainesville, Fla.	4	L. F. Schoonmaker
†Gannon College, Erie, Pa.	2	J. A. Selvaggi
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†Houston, University of, Houston, Texas	7	W. T. Kittinger
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*Illinois, University of, Urbana, and Chicago Division, Chicago, Ill.	5	J. E. Williams
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*Louisiana State University, Baton Rouge, La.	4	William E. Owen
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*Massachusetts, University of, Amherst, Mass.	12	F. H. Edwards
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*Michigan State University, East Lansing, Mich.	5	Mahmond A. Melehy
*Michigan, University of, Ann Arbor, Mich.	5	J. G. Tarboux
Milwaukee School of Engineering, Milwaukee, Wis.	5	R. J. Ungrodt
*Minnesota, University of, Minneapolis, Minn.	5	Paul A. Cartwrigh
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*Missouri School of Mines and Metallurgy, Rolla, Mo.	7	Claude J. Grimm
*Missouri, University of, Columbia, Mo.	7	J. C. Hogan
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†Texas College of Arts and Industries, Kingsville, Texas	7	Emerson Korges
*Texas Technological College, Lubbock, Texas	7	T. B. Stenis
*Texas, University of, Austin, Texas	7	R. R. Krezdorn
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*Toronto, University of, Toronto, Ont., Canada	10	J. E. Reid
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United States Naval Post-Graduate School, Monterey, Calif.	8	Allen E. Vivell
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*Virginia Polytechnic Institute, Blacksburg, Va.	4	Claudius Lee
*Virginia, University of, Charlottesville, Va.	4	J. M. Roberts
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*Washington, University of, Seattle, Wash.	9	F. D. Robbins
*Washington University, St. Louis, Mo.	7	Marvin J. Fisher
*Wayne University, Detroit, Mich.	5	Richard E. Kuba
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West Virginia University, Morgantown, W. Va.	2	Everette C. Dubbe
Wichita, University of, Wichita, Kans.	7	A. T. Murphy
*Wisconsin, University of, Madison, Wis.	5	W. B. Swift
*Worcester Polytechnic Institute, Worcester, Mass.	12	W. R. Grogan
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Yale University, New Haven, Conn.	12	J. C. May
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INDUSTRIAL NOTES

Larger Quarters. The Research Instrument Co., Portland, Oreg. has moved its operations to new and larger quarters, located at 7962 S. E. Powell Blvd., Portland 6, Oreg. The new facilities provide an increase in working area of 400% including space for additional expansion.

Miniature Transistor Transformers. The United Transformer Corporation, 150 Varick St., New York 13, N. Y., announces the addition of seven new types in their line of ultra-miniature *DO-T* transistor transformers. These *DO-T* units weight only 1/10 ounce and are fully hermetically sealed to *MIL-T-27A* specifications. Included in this new group of additional types are a number of 500-milliwatt units designed for push-pull transistor to 600-ohm line, a chopper input transformer, transistor interstage transformer, and a line to line matching transformer.

Preweighed Adhesive Compounds. These compounds for hermetic-sealing applications are now available in one-shot packages (mix, use, throw away). Developed by Bacon Industries because of the demand for precisely weighed amounts of adhesive compounds for sealing gyroscopes, the adhesives *FA-1* and *LCA-1* have been individually packaged in two parts to provide small, accurately weighed (to $\pm 3\%$) quantities of both adhesives and activator. In each type of compound, the adhesive is in a container sufficiently large to allow adequate mixing space for the activator. The activator is in sealed glass ampules to prevent contamination and evaporation. Technical Data Sheet *111A* contains further information on the new product and can be obtained by writing Eldon Fay, Sales Manager, Bacon Industries, Inc., 192 Pleasant St., Watertown, Mass.

AiResearch Phoenix Expands. Expansion of electronic and pneumatic control facilities at The Garrett Corporation's AiResearch Manufacturing Division in Phoenix, Ariz., totals 40,000 square feet of working area. The construction will house 500 workers engaged in the company's growing electronic and valve business. Office area totaling 24,000 square feet will be for engineering, sales, purchasing, and personnel people engaged in electronic and valve work, and 16,000 square feet are allocated for assembly and stores. The construction is the first step in a master plan which entails a 120,000 square foot building.

A Time-of-Flight Analyzer. **Radiation** Counter Laboratories, Inc., (RCL)—Nucleonic Park, Skokie, Ill., has signed a contract to produce the first commercial *1024*-channel neutron time-of-flight analyzer for Saclay Laboratories of the French Atomic Energy Commission in Paris, France. The RCL *1024*-channel analyzer measures neutron energy by determining the time it takes a neutron to travel from a reactor to a distant detector. It is the only instrument of its kind on the market.

Resistor Manufacture. The Vamistor Manufacturing Division of the Weston Electrical Instrument Corporation, 619 Frelinghuysen Ave., Newark 5, N. J., is now occupying expanded quarters in a new building recently completed in Union, N. J. Weston is a subsidiary of Daystrom, Incorporated. The Vamistor is the precision metal film resistor which has a special resistance alloy fused into the inner surface of a moisture sealed ceramic tube in a dispersed form. The unit, which will handle a full half-watt loading at 125 C, is virtually impervious to the effects of abrasion, thermal shock, and temporary overloads; in addition to having a temperature coefficient better than ± 50 ppm per degree C, it is noise-free with excellent high frequency performance. Vamistors are now furnished in resistance values up through 1 megohm.

Office Lobby to Match Outdoor Light. An astronomical clock will be used in the bronze Seagram tower building under construction at 375 Park Ave., New York, N.Y., to keep lobby lighting in step with daylight outside. This will equalize the light intensity for persons entering or leaving the building. Sunrise and sunset are registered by the clock automatically, and the light in the lobby will brighten as the day gets lighter, or get dimmer as the sunshine lessens, to maintain internally the same light level of sunshine. This use of light eliminates violent contrasts in light intensity between indoors and outdoors, and the lobby lighting blends with the natural light to dramatize the entrance. It is the first time light has been used for this purpose.

Lightweight Radio-Compass System. The exacting demands in engineering design of navigation and communication equipment for civilian and military aircraft has prompted extensive use of glass-base laminated plastics (NEMA Grade *G-5*) in Aircraft Radio Corporation's Type *21* subminiature Automatic Direction Finder (ADF), a 19.6 pound automatic radio compass system. The laminated plastic, manufactured by the Synthane Corporation, Oaks, Pa., is a continuous-filament woven-glass base grade bonded with a melamine resin, and possesses high flexural, compressive, shear, and impact strength combined with high resistance to flame, heat, and wide temperature changes. Although weight factors are always an important consideration in aircraft equipment, the relative lightness of Synthane Grade *G-5* was only one of many factors influencing choice of the material for the aircraft direction finder, which weighs less than a third of that of earlier ADF systems.

(*Continued on page 22A*)

Here G. D. Schott (right), Flight Controls Department head, discusses computer solutions of control and guidance problems with E. V. Stearns (center), Inertial Guidance Department head, and J. E. Sherman, Analog Computer Section head.

Lockheed Missile Systems announces new positions in

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Inquiries are invited from engineers possessing a high order of ability. Address the Research and Development Staff, Palo Alto 43, California.

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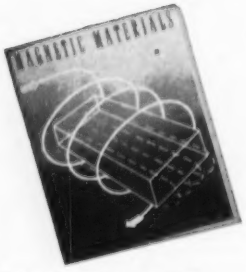

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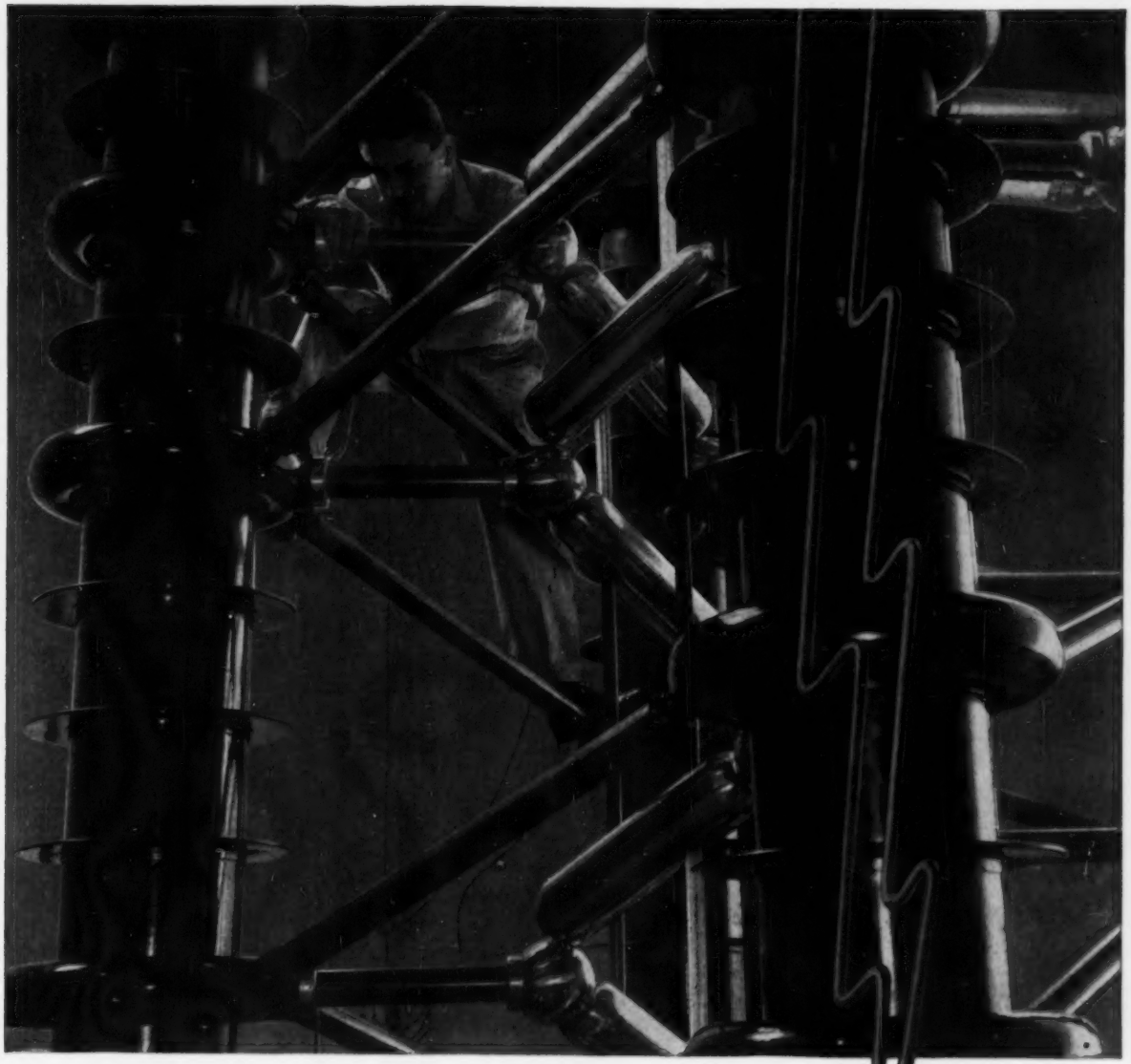

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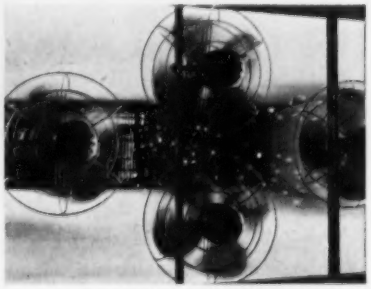
(Continued from page 18A)

Industrial Notes

Airborne Transistorized Computer. Philco Corporation, Government and Industrial Division (G and I), 4700 Wissahickon Ave., Philadelphia 44, Pa., has set a new first in the field of airborne electronics. The G and I Division has delivered its first high-speed transistor automatic computer (TRANSAC *C-1100*) which has been accepted by the United States Navy. The Navy is installing the unit in one of its jet fighters. The computer is designed to handle all computational problems encountered in the control of military aircraft while in flight.

Electron Irradiation. Aerojet General Nucleonics, manufacturer of nuclear reactors, is having its polyethylene reactor cores irradiated with 8 million volt electrons to give them better heat resistance. After fabrication, the cores are sent to Applied Radiation Corporation, 2404 No. Main St., Walnut Creek, Calif. where they are irradiated by one of Applied Radiation's high energy linear electron accelerators.

Flotation Classification System. Separation of "under" and "over" thickness parts fabricated from mica is being accomplished on a production-line basis through a novel "air flow" classification system. The flotation system was developed by, and is in operation at Ford Radio & Mica Corporation, 536-540 63rd St., Brooklyn 20, N. Y., a pioneer in precision mica fabrication for the electronics industry since 1917. Exacting classification of parts provide assurance of uniform performance



Ford Radio & Mica Corp. Photo

of such insulating parts in the ultimate application. The classification system is particularly effective in grading small spacers and bridges, insulating mica wafers used in electronic vacuum tubes, which are fabricated in thicknesses of from 0.006 to 0.015 inch. Tolerances are within ± 0.002 inch.

New Quarters. B. A. Wesche Electric Co. is now located at 9027 Shell Road, Cincinnati 42, Ohio, in the suburb of Blue Ash, some 11 air miles northeast of the company's old downtown plant site.

(Continued on page 24A)

ASCO literature simplifies choice of electromagnetic control

New catalogs offer design engineers important reference tools

MASTER CATALOG 57-S

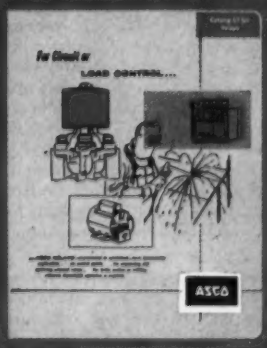
More than a catalog, this complete volume supplies comprehensive design engineering data on automatic transfer switches, remote control switches, contactors, relays, solenoids, and electric plant control.

For the engineering specialist who is concerned with components of the ASCO electromagnetic control line, individual catalogs are available covering:

57-S1 AUTOMATIC TRANSFER SWITCHES
. . . designed to transfer a load automatically from a normal source to an emergency source upon failure or reduction in voltage of normal source. For all classes of load, mechanically or magnetically held.

57-S2 REMOTE CONTROL SWITCHES
. . . for convenient and accessible control of power and lighting circuits from any number of control stations. For all classes of load, mechanically held.

57-S3 CONTACTORS
. . . designed to allow unlimited combinations, including multi-pole, special contact arrangements and materials, and other "engineered to fit" features. For all classes of load, normally open and normally closed, magnetically held.



57-S4 RELAYS
. . . magnetically and mechanically held in unlimited pole combinations – plus a highly diversified line of special purpose relays listed as standard catalog items.

57-S5 SOLENOIDS
. . . A-C and D-C, catalog listed or engineered to your requirements.

57-S6 ELECTRIC PLANT CONTROLS
. . . complete systems and components, paralleling, changeover, and alternating panels, load-demand controls, battery chargers and adapter units.

Additional technical literature . . .

Also available is the ASCO engineering study, "Factors to Consider in the Selection of Automatic Transfer Switches."

Catalog 201 on ASCO Solenoid Valves covers more than 1300 types – 2-, 3-, and 4-way with standard, explosion-proof or watertight enclosures–in a wide range of body materials.

Any of these important reference tools may be had simply by writing Automatic Switch Company – *on company letterhead only, please.*

Automatic Switch Co.
50-K Hanover Road, Florham Park, New Jersey
FRontier 7-4600

ASCO

BIDDLE
CORONA TESTING EQUIPMENT

. . . for non-destructive evaluation of electrical insulation in transformers, cables, capacitors and other electrical components.

Control cabinet and test transformer available as separate units on casters for mobility, for testing specimens with terminal capacitance up to 0.15 MUF and impedance to ground of 20,000 OHMS or more. (Power output maximum of 20 KVA at 20 KV 60 CPS.) On special order this equipment can be supplied for maximum output power at 20 KVA at maximum test voltage 80 KV 60 CPS.

Safety, simplicity, and reliability have been engineered into all Biddle Corona Testing Equipment. Care has been taken to make the indication of corona as simple and self-evident as possible.

For sensitive test equipment these sets are extremely rugged, and surprisingly easy to operate, even by personnel not specifically trained for making electrical measurements. All this without sacrificing sensitivity of corona detection and reproducibility of test results.

With the Biddle Corona Test Set non-destructive evaluation of insulation by corona testing is now practical as a production control of quality of insulating structures.

Whatever your requirements in this field of testing explore the complete line of Biddle Corona Testing Equipment—for complete details write for **Bulletin 66-IS.**

JAMES G. BIDDLE CO.

- ELECTRICAL TESTING INSTRUMENTS
- SPEED MEASURING INSTRUMENTS
- LABORATORY & SCIENTIFIC EQUIPMENT

1316 ARCH STREET
PHILADELPHIA 7, PA

(Continued from page 22A)

Industrial Notes

Chase & Sons, Inc. With main offices in North Quincy, Mass., and plants in Quincy and Randolph, Mass., this company has recently acquired a controlling interest in Gro-Cord Rubber Company, Lima, Ohio. Gro-Cord Rubber Company of Canada, Ltd., Tillsonburg, Ontario, wholly owned by Gro-Cord Rubber Company will continue to operate as a subsidiary as will the Alfred Hale Rubber Company, Inc. Chase & Sons, Inc. manufactures insulating tapes and other insulating materials for the cable and electrical industry with distribution throughout the United States, Canada, and Europe.

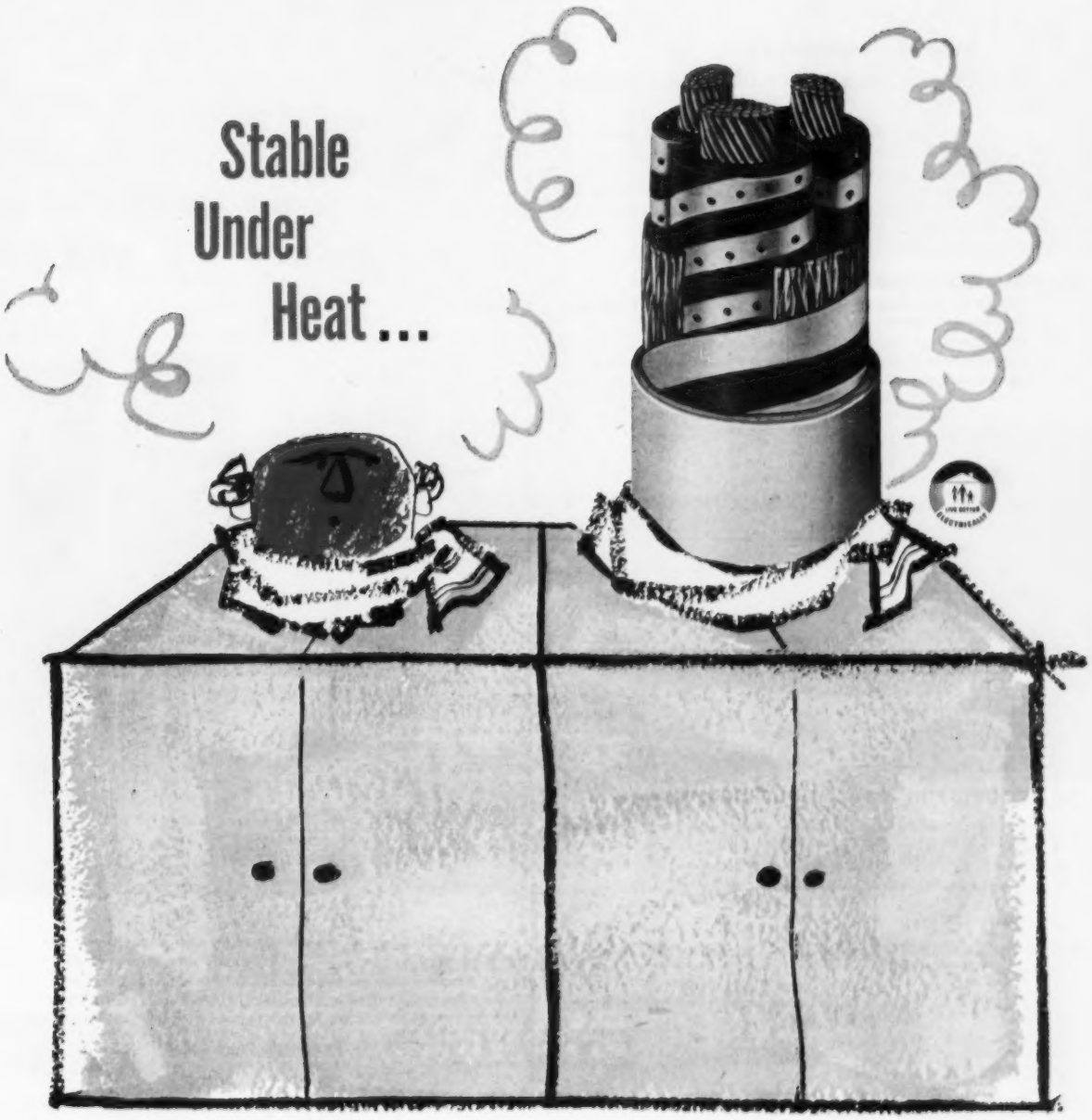
Hydroelectric Expansion. Water pouring through new equipment at Snoqualmie Falls adds 20,000 kw of hydroelectric power to the Puget Sound Power & Light Company, 860 Stuart Building, Seattle 1, Wash. With the new facilities, the plant's capacity is increased to 42,000 kw, nearly double its previous generation.

Sound Laboratory. Construction of a transformer sound laboratory has been begun at the Canonsburg plant of the Pennsylvania Transformer Division, McGraw-Edison Company, Box 330, Canonsburg, Pa. Officially designated as a Thomas A. Edison Research Laboratory, the new building will provide complete facilities for research on means to reduce the noise created by electrical equipment.

Expansion at Cooper. Plant facilities at Cooper Development Corporation (CDC), Monrovia, Calif., are being doubled because of increased activities in the design and production of high-altitude research rocket devices, meteorological rockets, infra-red equipment, special missile assemblies, and mercury-xenon illuminating equipment. The three-way expansion program involves a new plant in Baldwin Park, Calif., for production of electrical and electronic equipment; a facility at Fontana, Calif., for special rocket operations involving propellants and explosives; and a new addition at the main plant for metalworking and assembly operations.

Aquatic Reinforced Plastic Signs. For several years, lampreys, eel like fish, have been killing edible fish and seriously threatening the livelihood of many persons in the Great Lakes fishing area. The U. S. Fish and Wildlife Service, with the aid of Perry Plastics, Incorporated, Erie, Pa., is resolving the problem with the use of Laminac (registered trademark) polyester resin, a product of American Cyanamid Company, 30 Rockefeller Plaza, New York 20, N. Y. To combat the lamprey threat, electrically charged barrier lines have been stretched across the area where the lampreys return from spawning. The signs must be strategically placed to warn passers-by of the electrically charged water, and are posted on land as well as in the water.

(Continued on page 30A)



the Tellurium Lead Alloy Sheath on Roebling Paper Power Cable

Sheath temperatures during wiping operations are in the range of 400°F, emphasizing the importance of heat stability. And you'll find that Roebling Tellurium Lead Alloy Cable Sheath retains its excellent creep resistance and bending fatigue resistance even after being subjected to this high temperature.

This is just one of the *extra-life* qualities built into Roebling Paper Power Cable with Tellurium Lead Alloy Sheath. Learn more about this exceptionally serviceable cable that offers so many savings. Write today for free, new, illustrated booklet that tells the whole story! Electrical Wire Division, John A. Roebling's Sons Corporation, Trenton 2, New Jersey.

ROEBLING

Branch Offices in Principal Cities
Subsidiary of The Colorado Fuel and Iron Corporation

WILEY books

1. AN INTRODUCTION TO JUNCTION TRANSISTOR THEORY

By R. D. MIDDLEBROOK, California Institute of Technology

A clear and logical presentation of the basic development of transistor electronics, from fundamental physical principles to practical circuit representations. Much of the material has never appeared in book form. Makes an indispensable reference for on-the-job problems.

1957. 296 pages. 144 Illus. $8.50.

2. TRANSISTOR CIRCUIT ENGINEERING

Edited by RICHARD F. SHEA. Eight co-authors, all of the General Electric Company.

Up-to-date information on transistors with emphasis on the practical engineering aspects. Shows you how to do actual circuit designs and develop usable circuits—how to build successful audio amplifiers, radio frequency amplifiers, etc., using available transistors; and how to combine these elements into radio receivers, TV sets, and high fidelity audio systems.

1957. 468 pages. Illus. $12.00.

3. AN INTRODUCTION TO SEMICONDUCTORS

By W. CRAWFORD DUNLAP, JR., General Electric Co.

A thoroughly practical and informative work that surveys all the important aspects of semiconductors, from research to devices.

1957. 417 pages. 268 Illus. $11.75.

4. DIGITAL COMPUTER PROGRAMMING

By D. D. McCRACKEN, General Electric Co.

A lucid, down-to-earth presentation of the practical aspects involved in actually working with automatic digital computers, plus a clear-cut picture of the basic fundamentals underlying this fast-growing field.

1957. 253 pages. Illus. $7.75.

5. PROGRESS IN SEMICONDUCTORS, Volume I

Edited by ALAN F. GIBSON, Radar Research Establishment, Malvern U.K.; P. AIGRAIN, Université de Paris; and R. E. BURGESS, University of British Columbia

Latest information on semiconductors by 8 specialists in the field.

1956. 220 pages. Illus. $8.00.

6. SEMICONDUCTOR ABSTRACTS, Volume III—1955 Issue

Edited by E. Paskell, Battelle Memorial Institute. Sponsored by The Electrochemical Society.

1957. 322 pages. $10.00.

7. SCIENTIFIC FRENCH

By WILLIAM N. LOCKE, M.I.T.

1957. 112 pages. $2.25.

8. SCIENTIFIC GERMAN

By GEORGE E. CONDOYANNIS, St. Peter's College

1957. 163 pages. $2.50.

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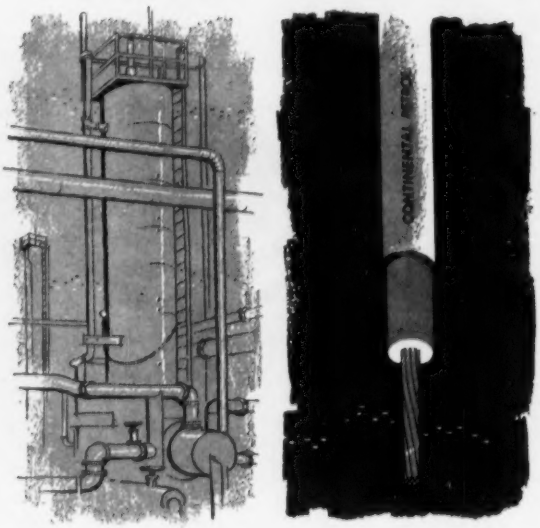
now! *a low cost gasoline/oil resistant insulated wire . . . the NEW Nylon-jacketed*

CONTINENTAL
PETROL WIRE



APPROVED BY UNDERWRITERS' LABORATORIES, INC.

Looking for a low-cost gasoline and oil resistant insulated wire? An insulated wire approved for use in wiring gasoline pumps and in refineries BUT at lower cost than lead jacketed rubber insulation? Then you've been looking for this NEW Continental PETROL wire.

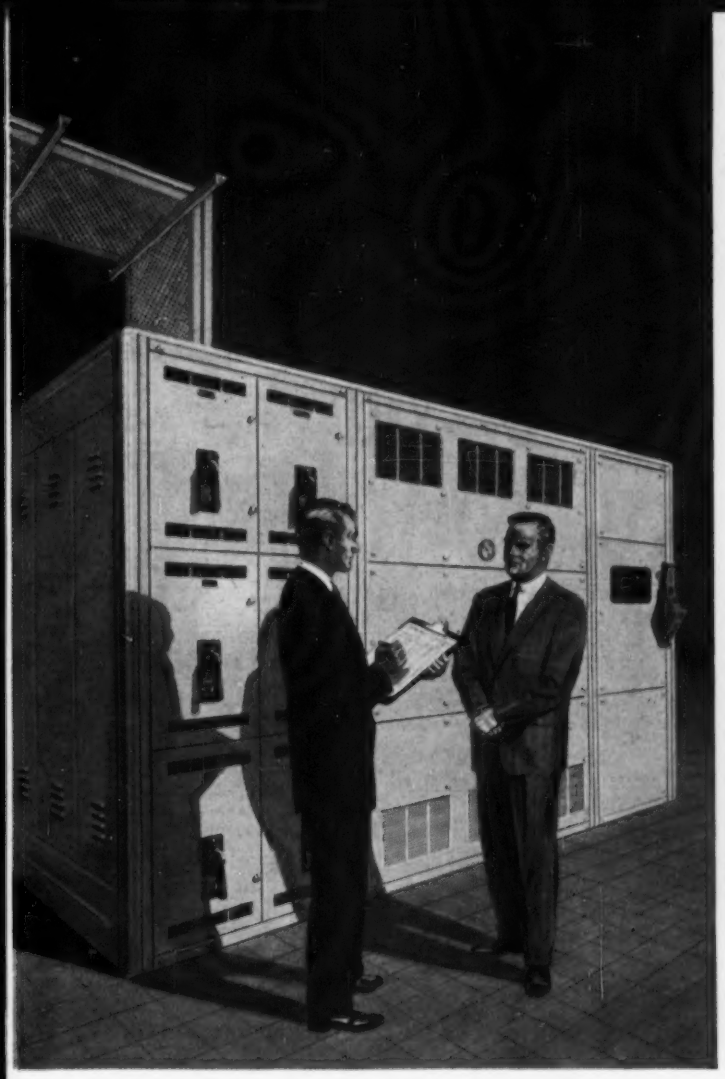
Nylon-jacket over thermoplastic insulation, PETROL wire is not affected by most oils, acids and alkalis. It is approved by Underwriters' Laboratories for 30°C in gasoline . . . 60°C in oil or air.

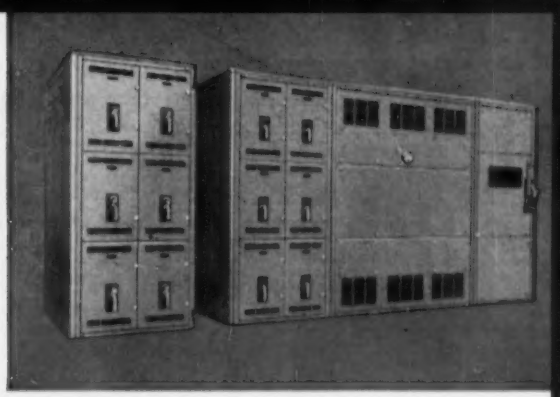
Available in sizes from 14 to 6 AWG . . . in a rainbow-range of colors. For more information on the new Continental PETROL wire, outline your requirements in a letter and mail to us immediately. A Continental field engineer will be glad to help with any insulated wire problem in your area.

FREE 72-page catalog of the complete line of Continental Insulated Wire and Cable available on request. Send for your copy today.

Continental
WIRE CORPORATION

WALLINGFORD, CONNECTICUT
YORK, PENNSYLVANIA





Standardized construction of BullDog Unit Substations allows for easy expansion. Units are interchangeable. Changes and additions can be made quickly and economically. The substations are of the secondary type . . . rated up to 600 volts . . . and are available with all types of transformer equipment.

BullDog field engineers offer specialized help in preparing a system tailored to your present and future power needs. They have the knowledge and experience to co-ordinate top-quality, creatively engineered BullDog products into an integrated, efficient electrical system that stays modern.

Plan your power for production results!

New BullDog secondary Unit Substations answer vital needs in the operation of modern industrial plants. They bring the overall economies of high-voltage distribution—plus providing adequate facilities for future expansion. And by bringing higher voltages closer to consuming equipment, Unit Substations boost machine efficiency to maximum productivity. Valuable floor space is saved, too, through an integrated unit which houses transformer, switchgear and other components.

Let the BullDog field engineer give you all the facts—show you how Unit Substations are the starting point of a *planned* power system by BullDog, which adds materially to plant safety, economy, and production efficiency!

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BullDog Electric Products Company, Detroit 32, Michigan • A Division of I-T-E Circuit Breaker Company • *Export Division:* 13 East 40th St., New York 16, N.Y. *In Canada:* BullDog Electric Products Co. (Canada), Limited, 80 Clayson Rd., Toronto 15, Ont.

IF IT'S NEW . . . IF IT'S DIFFERENT . . . IF IT'S BETTER . . . IT'S

BULLDOG

ELECTRIC PRODUCTS COMPANY

A DIVISION OF I-T-E CIRCUIT BREAKER COMPANY

PRIMARY UNIT SUBSTATIONS

CUSTOM BUILT FOR YOU —AT NO EXTRA COST

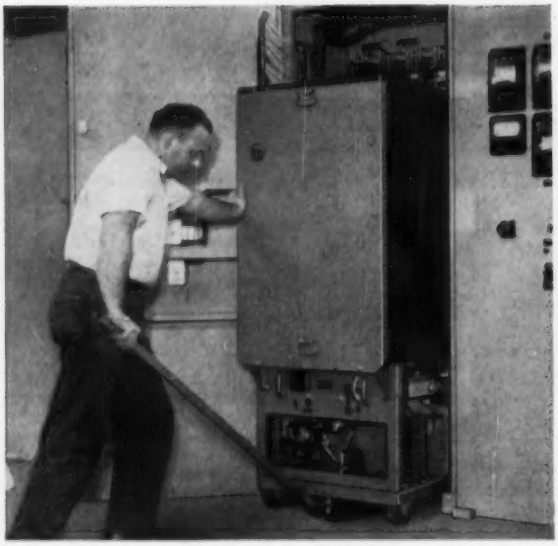
Here at I-T-E, complete primary unit substations are custom designed and engineered to meet your particular requirements. I-T-E engineers skillfully knit together quality I-T-E substation components in a way to give you the advantages of versatility, reliability, safety and convenience.

Particular emphasis is placed on ease of installation to meet all your requirements for growth and relocation, with full regard to an appearance that fits well into your surroundings.

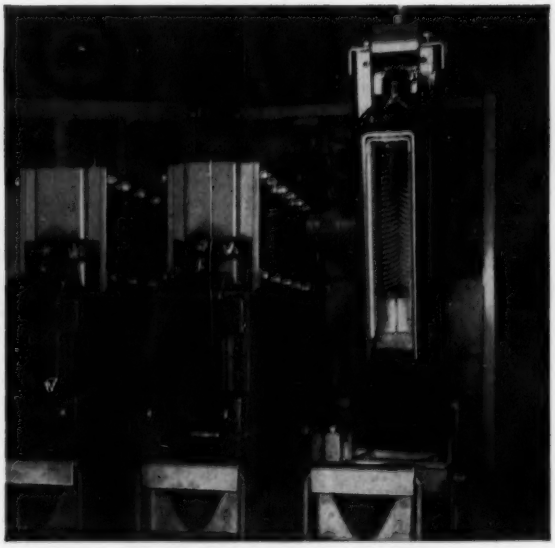
Typical I-T-E quality manufacturing standards further insure that your substation will give you the maximum reliability and performance at the lowest cost. Delivery can be made in accordance with your own construction schedule. You can save time, trouble and money in completing the final job.

I-T-E primary unit substations are available for any application and in any standard rating. For details, call the I-T-E sales office near you. Or write I-T-E Circuit Breaker Co., 19th & Hamilton Sts., Philadelphia 30, Pa.

Engineered to insure the best value

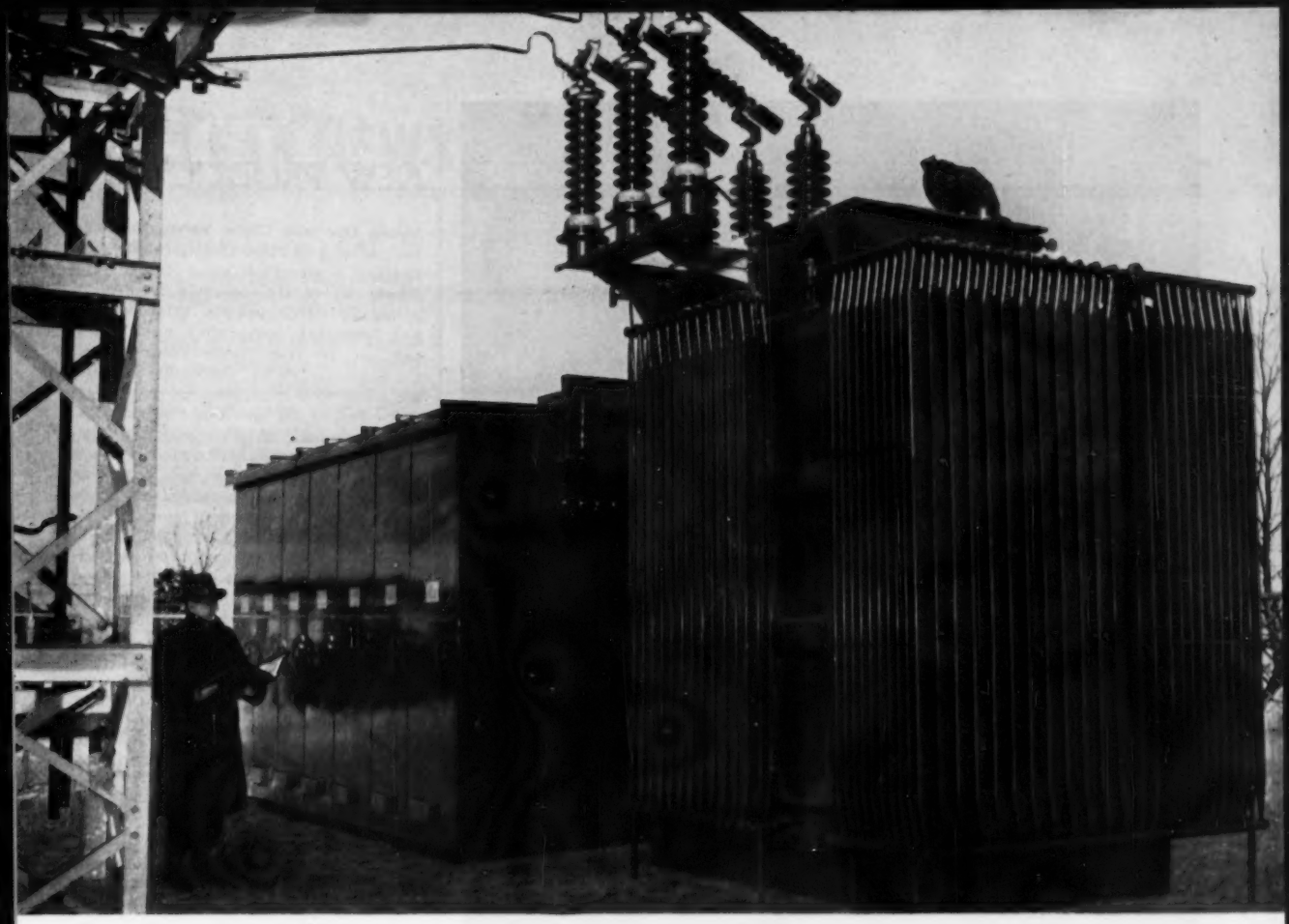


Horizontal drawout air circuit breakers. Even heavy 13.8-kv circuit breakers roll out easily on permanently attached wheels. Safety shutters automatically close over bus openings when breaker is moved to test position or from enclosure.

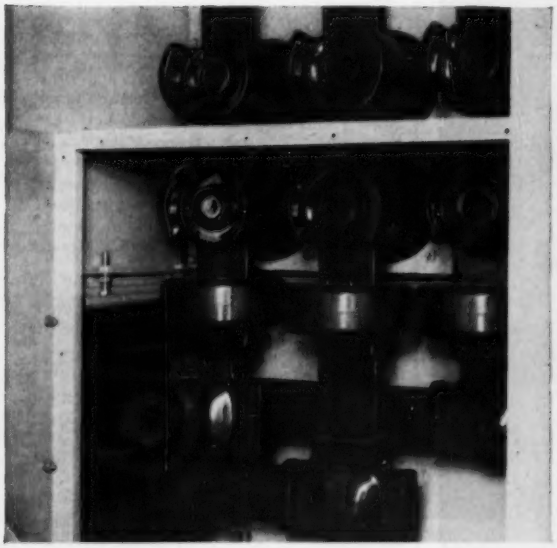


Positive arc interruption. Double coil, closed iron magnetic circuit produces intense magnetic effect, drives arc rapidly and uniformly between plates in arc chute, where it is extinguished, giving faster interruption, longer arc chute life.

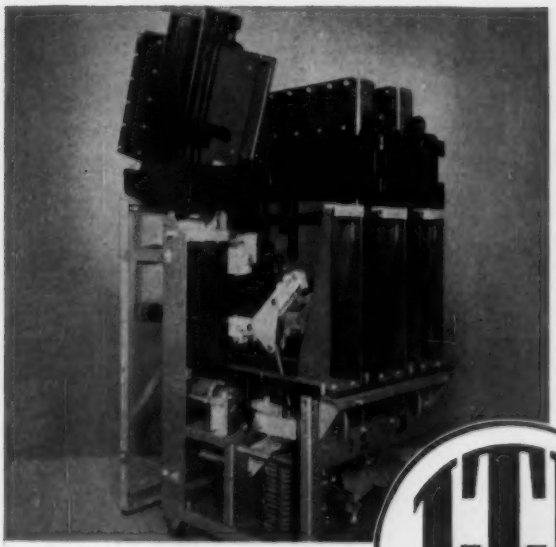
I-T-E CIRCUIT BREAKER COMPANY • Switchgear Division



and the most reliable performance



Fully isolated main bus with flame-retardant insulation. Bus is held in alignment against short circuit stress by porcelain bus supports. Flame-retardant insulation covers entire bus, including porcelain primary disconnect housings.



Simplified maintenance. Pivoting arc chutes simplify routine inspection and upkeep. Auxiliary devices are positioned to permit easy access.

I-T-E

IN CANADA: EASTERN POWER DEVICES LTD.

profile of a
very special guy
...the Lenkurt
engineer

- Special, because with Lenkurt — leading specialist in telecommunications — he has found the challenges and inspirations, the responsibilities and recognition that add up to a truly satisfying career.
- Special, because he is planning and building the communications systems of tomorrow.
- Special, because at San Carlos, on the sunny San Francisco peninsula, he has found the ultimate in what is known the world over as "California living."

A few very special guys whose field of interest is communications will find these opportunities at Lenkurt most attractive:

Project Engineers — High level positions requiring at least 3 years professional history in communications equipment design, component development, or systems planning. Graduate study desirable.

Electronics Engineers — Knowledge of circuit design including amplifiers, oscillators, modulators, and regulators, utilizing tubes and transistors. Good background in test procedures and test equipment; BSEE with communications option desirable.

Assistant Electronics Engineers — Graduate engineers who have an interest in circuit analysis and experimentation and want to gain experience as members of an engineering team working on advanced development projects.

Lenkurt ELECTRIC
San Carlos 3, California

Please send your resumé to Dan Foster, Engineering Placement Manager

(Continued from page 24A)

NEW PRODUCTS

Motor Operated Globe Valve. New and unique in principle, the patented "New England" motorized valve incorporates almost all of the desirable features of automatic valve operation in one simplified, powerful, inexpensive unit. Available in 10 sizes, three voltages, and three timing cycles, this unit is easily adaptable to a great number of applications. Despite its low cost, this unit features automatic disc compensation, extremely tight shut-off, 150 pounds pressure capacities on most sizes, no mounting restrictions, permanent lubrication, quiet positive operation without linkage, machine-cut hardened steel gears, only eight moving parts, and compact size. For further information, contact New England Gear Works, South End Rd., Southington, Conn.

Radar for Private Use. Radar-Eye is a motion-detection instrument that provides space protection. This device is the most modern method of protecting industrial and commercial business against vandalism, burglary, or intrusion. Radar is employed to detect any movement within an operating radius of 25 feet in any direction from the instrument's antenna. Invisible radar waves, sensitive to any movement, instantly turn on floodlights and then set off a screaming siren. Intruders cannot crawl over it, slide under it, cut through it, or in any way tamper with either the unit or wiring system without setting off the alarm. Manufactured by Radar-Eye Corporation, North St., Natick, Mass., the installation is sold through franchized distributors nationwide.

Aluminum Foil Wire Markers. A line of aluminum foil wire markers has been added to the group of selfsticking products marketed under the trade name Speedy Marx. Aluminum markers are furnished on quick-release dispensing cards which have been precut for easy handling, and can be applied instantly without tools. For additional information, write, phone, or wire North Shore Nameplate, Inc., 214-2 Northern Blvd., Bayside 61, N. Y.

Dust Collector. Industry has been offered a new tool for dust collecting chores. It is a dust collector one-tenth to one-twentieth the size of comparable equipment. Called the Joy Microdyne dust collector, the unit is a wet, inertial type which has an efficiency greater than any comparable wet type collector according to the company. Test figures show that the Microdyne has an efficiency of 99+% in collecting dust particles of five microns or greater (a micron is equal to one-twenty-five-thousandth inch). For further information contact Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.

(Continued on page 36A)

NUCLEAR NEWS FROM ATOMICS INTERNATIONAL

Continuing Progress at AI Advances Nuclear Technology For Many Tasks, in Many Lands

Highlighting progress in the many and diversified reactor programs at Atomics International are significant developments in the two major power reactor approaches underway by AI for the Atomic Energy Commission—the Sodium Reactor Experiment and the Organic Moderated Reactor Experiment.

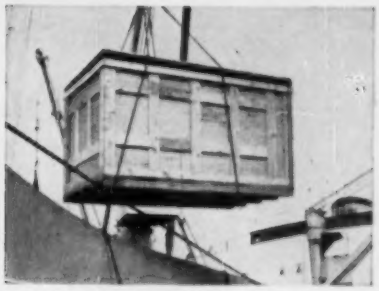
Forecasts Confirmed. On April 25 the 33rd fuel element was introduced into the SRE, and sustained nuclear fission was achieved. The critical loading confirmed earlier calculations. On July 12 heat from the SRE reactor was used by the Southern California Edison Company to generate electricity. This power was fed over utility lines to Edison consumers. Data obtained from the SRE will be used in the design of a 75,000 kw Sodium Reactor power plant proposed for the Consumers Public Power District of Nebraska.

Power Ashore, Propulsion Afloat. Similar studies are starting on the OMRE, recently constructed at the AEC's National Reactor Testing Station in Idaho Falls. This program will assist in the design of two 12,500 kw power stations, one in Piqua, Ohio, and another in a Latin American country. At the same time, the Organic Moderated Reactor is under study as a most promising nuclear propulsion system for the special needs of supertankers.

Reactors for the World. The Armour Research Reactor, first private industrial nuclear facility, is now being followed by a stream of similar research reactors—for Japan, Denmark, West Germany, West Berlin and Italy—constructed, shipped, and installed by Atomics International. AI's latest development is the compact Laboratory Reactor, available on a short delivery schedule at very low cost to meet the need for nuclear training and research in universities and industrial laboratories.

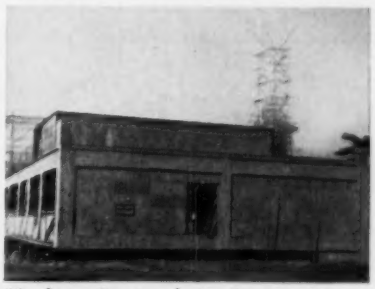
ATOMICS INTERNATIONAL is a leading designer and builder of reactors for America and for the world. For help on your reactor plans, write: Director of Technical Sales, Department EE-74, ATOMICS INTERNATIONAL, P. O. Box 309, Canoga Park, California. Cable Address: ATOMICS.

Critical Moment: On April 25, the SRE achieved sustained nuclear fission. Electricity was generated on July 12.



Destination—Denmark: Nuclear reactor components from AI are hoisted aboard a freighter for Copenhagen.

For Land and Sea: A versatile nuclear reactor concept—the OMRE.



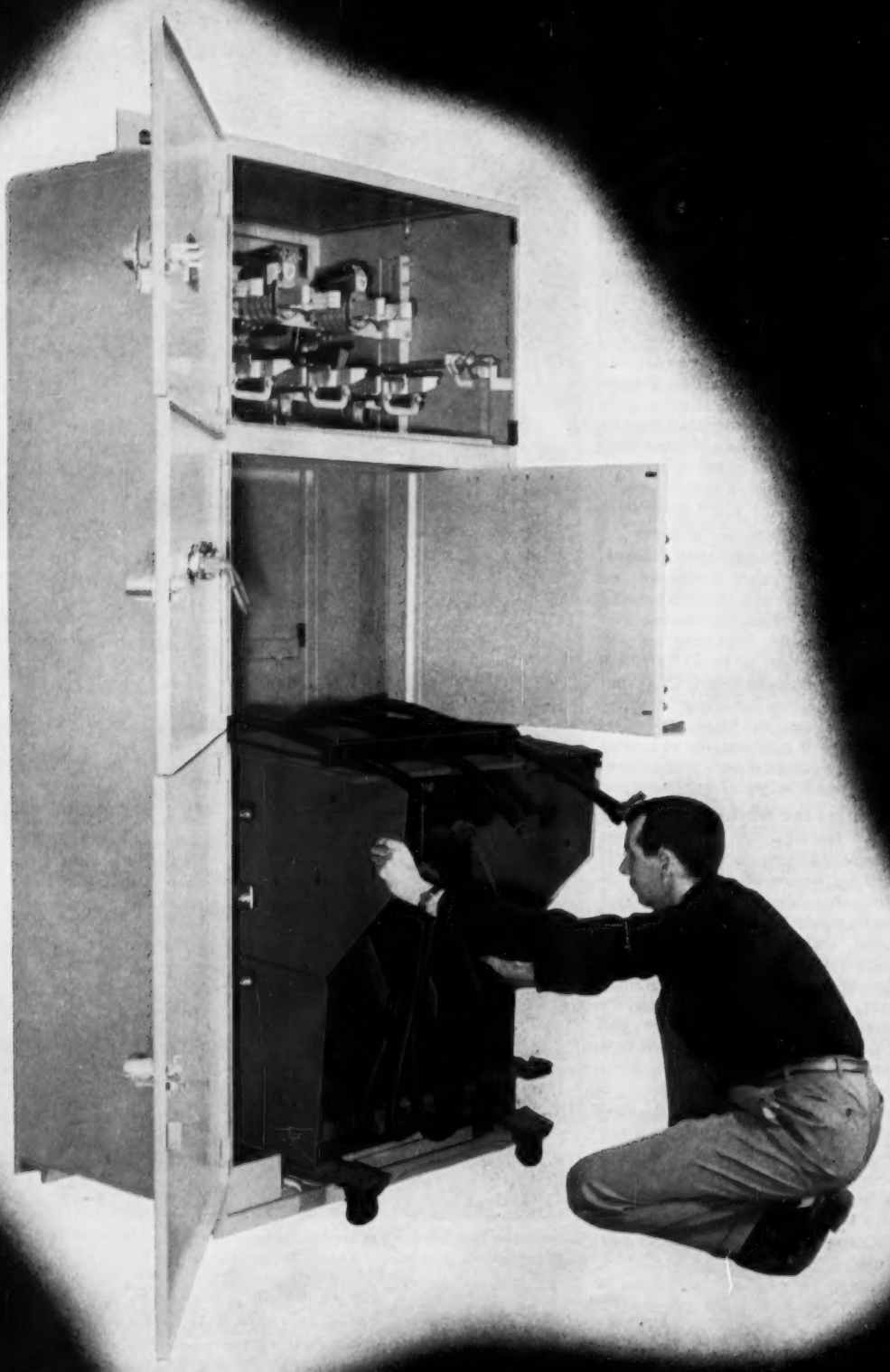
Nuclear Research in Japan: Home of Far East's first reactor will be Japan's Atomic Energy Research Institute.

New Laboratory Reactor: Eight-foot-high tank contains fully functional core, coolant and moderator.

Reactor Hardware for Germany: Components for two German reactors in work at ATOMICS INTERNATIONAL.

ATOMICS INTERNATIONAL
A DIVISION OF NORTH AMERICAN AVIATION, INC.
PIONEERS IN THE CREATIVE USE OF THE ATOM

HIGH-VOLTAGE MOTOR CONTROL.....



LEADER IN DESIGN AND PERFORMANCE

GENERAL ELECTRIC LIMITAMP* STARTERS OFFER ROLL-OUT CONTACTOR UNITS FOR EASIER INSTALLATION

Today's General Electric Limitamp starters are designed to bring you the utmost in installation ease, speed, and economy.

Key feature of this cost-cutting design is the caster-mounted contactor unit which can be easily rolled into or out of the Limitamp enclosure. After swinging out the hinge-mounted low-voltage panel, and before rolling in the contactor unit, the installation man can walk right inside the enclosure to make connections quickly and conveniently.

Once connections are completed, the panel can be closed and ready to operate within minutes. Limitamp panels control and protect motors rated 2300 to 4800 volts and ranging up to 3000 horsepower.

MORE LIMITAMP CONTROL FEATURES

Fast, economical installation is but one benefit of General Electric Limitamp control. There are many more. For instance:

- Extra five-square-foot space savings on large motor applications by using higher capacity fuses to eliminate need for extra fuse cabinet.
- Increased personnel safety provided by three-phase disconnect switch.
- Flexible arrangement of units and added space savings, with all connections made from front.
- Complete range of modifications to meet any installation requirement.

REALIZE THESE BENEFITS NOW

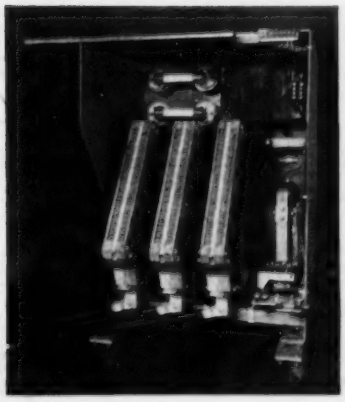
Don't be satisfied with "old-fashioned" high-voltage motor control: Specify General Electric's Limitamp control—*leader in design and performance.* Contact your G-E Apparatus Sales Office today, or write Section 783-2, General Electric Company, Schenectady, New York.

Industry Control Department, Roanoke, Virginia.

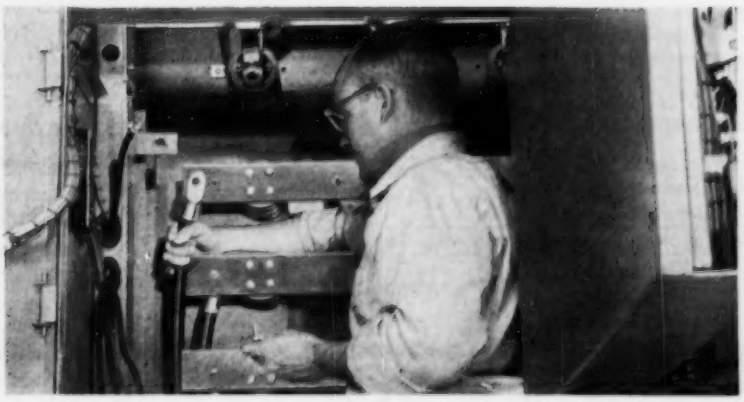
*Reg. Trade-mark of General Electric Company.

Progress Is Our Most Important Product

GENERAL ELECTRIC

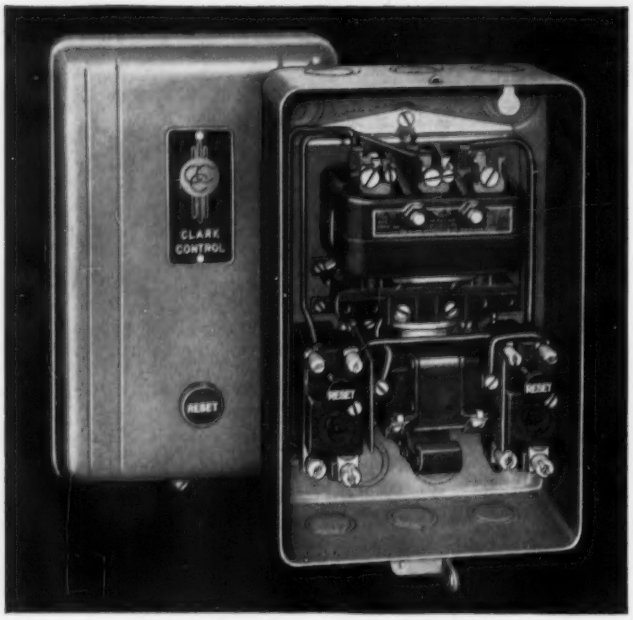


MAINTENANCE EASY on contactor; generally devices are front-removed.



THERE'S AMPLE SPACE to stand inside enclosure and make necessary connections. Yet entire control requires 50% less floor space than before.

CLARK Type "CY" Starters, sizes 0 and 1, now have higher NEMA horsepower ratings



As shown in the table below, NEMA maximum horsepower ratings for size 0 and 1 AC magnetic across-the-line starters have been increased. Clark Type "CY" starters now available to meet these new standards will, in many cases, permit you to meet your requirements with smaller sizes. You can at once take advantage of the money and space savings made possible by this re-rating.

CHANGES IN NEMA STANDARDS FOR MAXIMUM HORSEPOWER RATINGS OF AC MAGNETIC STARTERS AND CONTACTORS

SIZE AND VOLTAGE RATINGS	MAXIMUM HP RATINGS	
THREE PHASE	OLD	NEW
Size 0 110V	1½	1½
Size 0 208/220V	2	**3**
Size 0 440/600V	3	**5**
Size 1 110V	3	3
Size 1 208/220V	5	**7½**
Size 1 440/600V	7½	**10**
SINGLE PHASE		
Size 0 110V	1	1
Size 0 208/220V	1½	**2**
Size 0 440/600V	2	**3**
Size 1 110V	1½	**2**
Size 1 208/220V	3	3
Size 1 440/600V	5	5

NOTE: HP ratings for plugging and jogging duty have not been revised.

IN ADDITION TO COST AND SPACE SAVING BENEFITS OF THE NEW NEMA RATINGS, CLARK Type "CY" STARTERS OFFER MANY OTHER ADVANTAGES:

Greater Dependability and longer life

- Heavy-duty mill-type construction.
- Large silver-to-silver twin-break contacts.
- Vertical lift, free-floating magnet uses no springs; pull characteristic assures positive contact closing and keeps magnet slam to a minimum.

Easier Maintenance

- Contacts and contact springs quickly and easily inspected—without tools.
- All parts readily accessible and replaceable from front without removal from panel or enclosure—screwdriver and wrench only tools needed.
- Magnet coils easily replaced.

Simplified Installation

- Generous wiring space.
- All terminals face the front.
- Pressure-type terminals line and load.

...and many others

These increased horsepower ratings for AC controls will be adopted for all forms of Clark across-the-line starting equipment.

Revised Clark Catalog sheets and price lists covering the new NEMA ratings are available on request.

The **CLARK CONTROLLER** *Company*

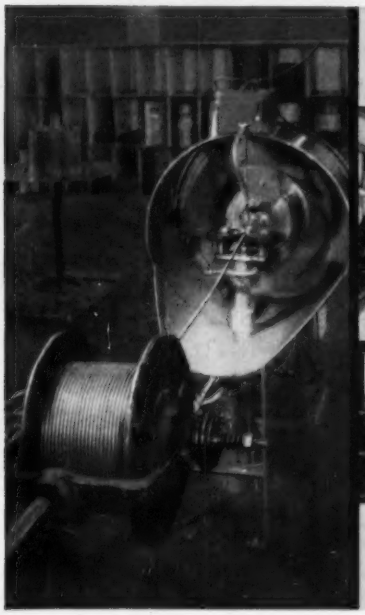
Everything Under Control — 1146 East 152nd Street • • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

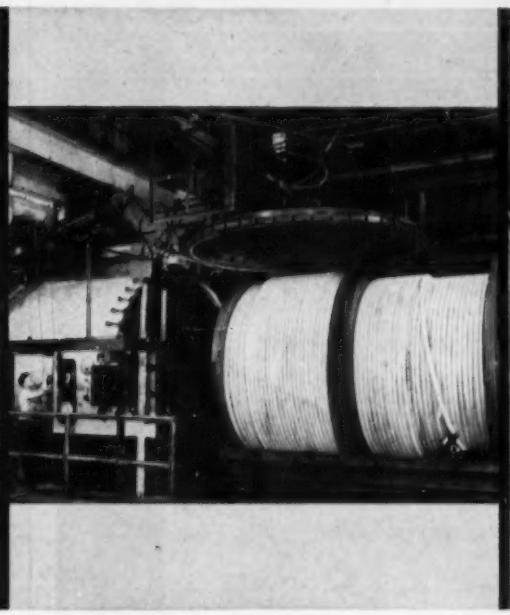
GENERAL CABLE

PAPER INSULATED
VERSATILE · RELIABLE
POWER CABLES

Manufactured at BAYONNE, N. J. • ST. LOUIS, MO. • EMERYVILLE, CALIF.



This machine forms steel strip into helical coil ducts or channels for use in gas filled or oil filled cable.



Impregnating Tank utilized in the heat-vacuum drying and oil impregnation steps in the manufacture of Paper Power Cable.

Large Cabling Machine used in cabling individually insulated conductors into multiple conductor assemblies.

- **SOLID TYPE**
- **LOW PRESSURE GAS FILLED**
- **LOW PRESSURE OIL FILLED**
- **PIPE TYPE**
  - **High Pressure Gas Filled**
  - **High Pressure Oil Filled**

The excellent operating record over many years and the superior electrical characteristics of paper insulated cable highly recommends its use for all power applications. Paper Power Cable is a predominant type in preference and use for voltages above 5 KV.

General Cable Corporation is equipped with the finest modern facilities for paper taping and with many years of know-how is in a position to supply a high quality product for all low and high voltage applications.

GENERAL CABLE CORPORATION
420 Lexington Avenue, New York 17, N. Y.
Offices and Distributing Centers Coast-to-Coast

for quality and economy... **specify GENERAL CABLE**

(Continued from page 30A)

New Products

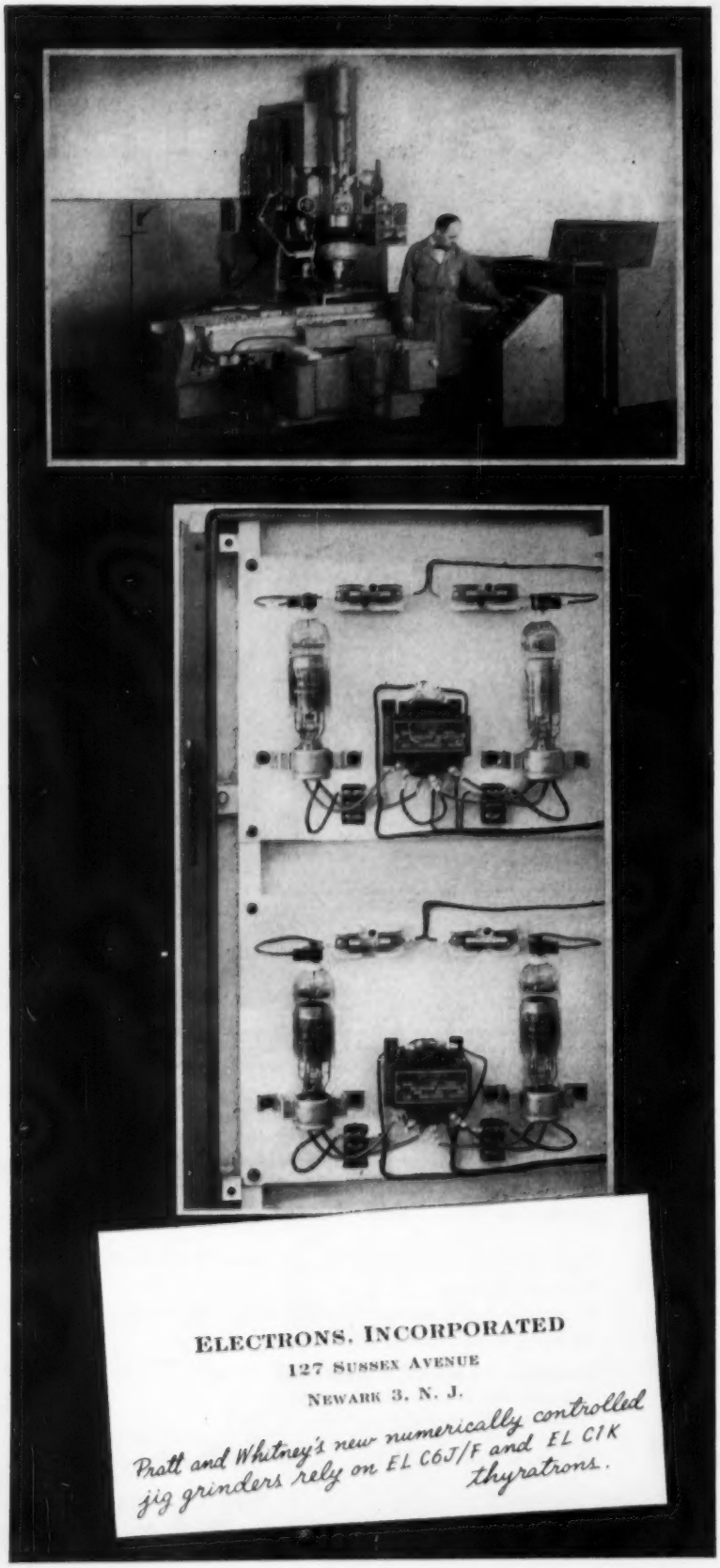
Automatic Control of Test Limits. A compact, precision-made device, called the Programmer Counter, that is used to turn on and off test appartus whose limits are sensed by strain gauges, thermocouples, or any other transducers that have a maximum output not exceeding 100 millivolts d-c has been developed by Spar Engineering & Development, Inc., Wyncote, Pa. The unit eliminates the need for manual control of test cycling and simplifies the setting up of equipment each time a test is to be made. The Programmer Counter is said to be a stable, precision, millivolt electronic relay having adjustable energizing and release thresholds and dpdt 15-amp contacts. Additional details may be obtained from the company on inquiry.

Miniature Cable Connectors. A subminiature series of r-f coaxial cable connectors has been put on the market. The series is designated *DM* and includes 12 different groups of jacks, receptacles, and adapters. These *DM* connectors are only half the size of BNCs, yet can withstand a cable pull of better than 50 pounds. They meet *MIL-C-5015* specifications and provide vibration proof coupling. Complete details and specifications for subminiature *DM* connectors are contained in Catalog *201-B*. Write Dage Electric Company, Inc., 67 No. Second St., Beech Grove, Ind.

Ceramic for Hermetic Seals. A ceramic material for hermetic seal applications at high temperatures is now available. Known as Ceramicite, the compound bonds physically to most stainless steels. The thermal expansion of Ceramicite is similar to these metals. Seals embodying Ceramicite have the exceptional ability to withstand severe physical and thermal shocks without leaks or cracking. Further information regarding Ceramicite seals appears in Bulletin *1587*, available from Consolidated Electrodynamics Corporation, 300 No. Sierra Madre Villa, Pasadena, Calif.

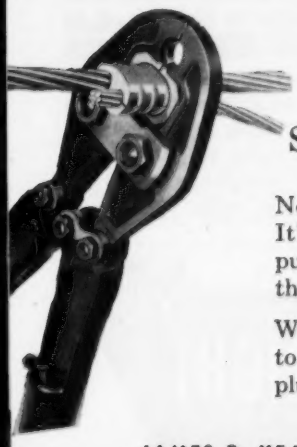
Miniaturized External Anode Tube. Value conscious engineers engaged in the design of military and civilian electronic equipment will find this miniaturized and ruggedized thermionic power diode a useful component for modern airborne instrumentation, especially missile guidance equipment. Designed for air or liquid immersed operation, the *545* will provide long reliable service under the most severe environmental conditions. Weighing less than 0.7 ounces, the tube is 2 inches long, 7/8-inch wide, and has a shock rating of 300 g. Detailed rectifier and clipper diode data available on request. United Electronics Company, 42 Spring St., Newark, N. J. Write for pamphlet *CDS-1*.

(Continued on page 40A)


ELECTRONS, INCORPORATED
127 SUSSEX AVENUE
NEWARK 3, N. J.
Pratt and Whitney's new numerically controlled jig grinders rely on EL C6J/F and EL C1K thyratrons.

Now...**KEARNEY** puts the inhibitor in for you!

Each operation of this machine forcefully applies the right quantity of Kearnalex within the jaws of the Squeezon.



it's automatically applied inside the Squeezons . . . at the KEARNEY Plants

Now there's no need to take up time on the job applying inhibitor to each connection. It's already there—in the proper place—in the proper quantity—because KEARNEY puts it inside the jaws of these Squeezons at the plant under ideal conditions . . . then packages each Squeezon in a heat-sealed plastic bag.

When the lineman installs the Squeezon on conductors, application of the Kearnalex to all necessary surfaces is *automatic* and *complete.* Convenient . . . time-saving . . . plus protection from corrosion and oxidation. Order your stock today!

JAMES R. KEARNEY CORPORATION, *General Offices:* 4224-42 Clayton Ave., St. Louis 10, Mo.

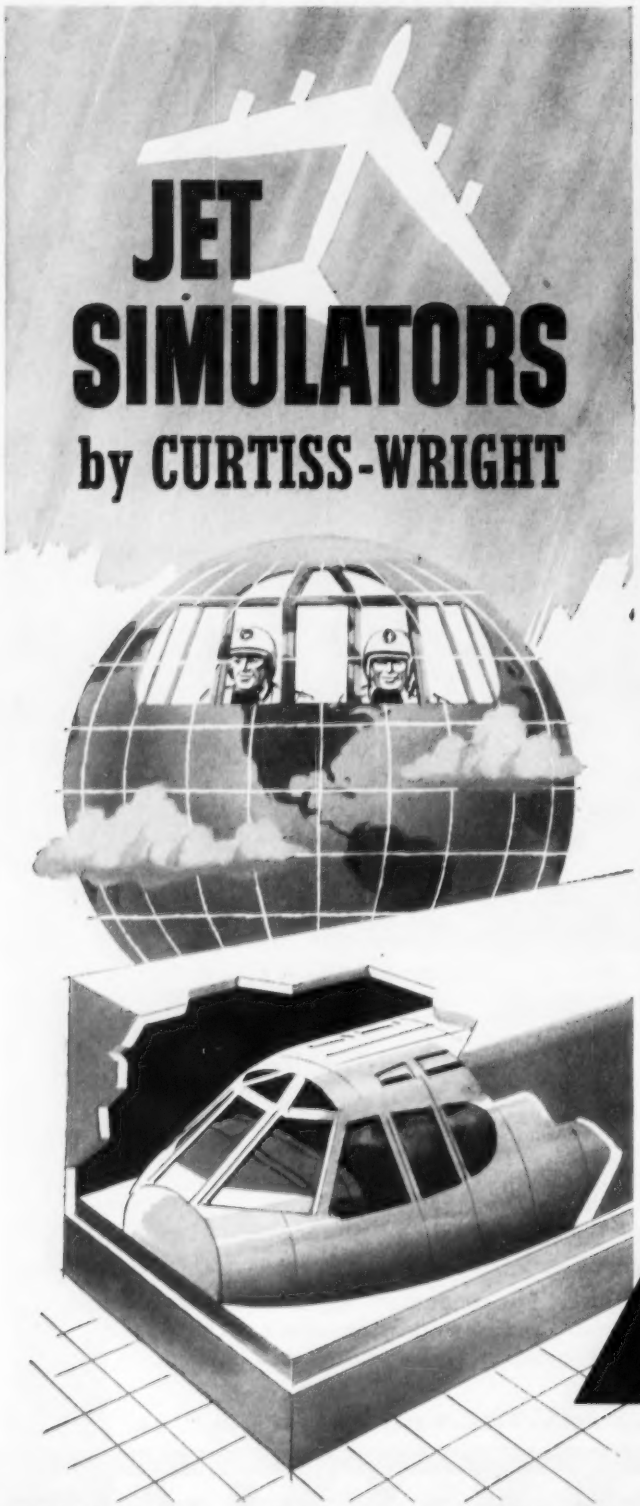
for BETTER CONSTRUCTION
SAFER MAINTENANCE
Specify

KEARNEY SQUEEZONS

JAMES R. KEARNEY CORPORATION ST. LOUIS, MO.

The Mark of Quality

Plants at: ST. LOUIS · FAYETTEVILLE, ARKANSAS · SHENANDOAH & CLARINDA, IOWA — GUELPH, ONTARIO, CANADA



Crews for U.S. Air Force Giant BOEING B-52 Jet Bomber pre-fly GLOBAL MISSIONS in the electronic SIMULATOR

Before crews of the USAF's biggest and fastest bomber take to the air, they have mastery of their aircraft. Hours of flying in the Boeing B-52 Simulator built by Curtiss-Wright have coordinated each man to his job . . . and the crew to its team function . . . down to the exact reading of every instrument of the plane in flight.

Similarly, integrating the coming jet transports into today's complex traffic patterns calls for experience that can no longer be gained in the air alone. Crews must be acquainted with new flight and communications procedures, holding techniques . . . with new navigation aids and airborne equipment. This calls for precision flight simulation — on the ground. Already, such major airline operators as Pan American World Airways have planned DC-8 and Boeing 707 familiarization programs built around Jet Simulators designed by Curtiss-Wright. The airlines and the military alike have selected Curtiss-Wright on the basis of its proven experience with every type of Simulator.

Simulators by Curtiss-Wright realistically reproduce every aspect of aircraft operation, with the highest precision and fidelity in the industry. They add to the safety of flight, save millions of dollars and thousands of man-hours yearly for both commercial and military operators.

ELECTRONICS DIVISION
CURTISS-WRIGHT
CORPORATION • CARLSTADT, N. J.

YOUNG MEN! JOIN THE U. S. AIR FORCE
Investigate Career Opportunities at Your Nearest Recruiting Office

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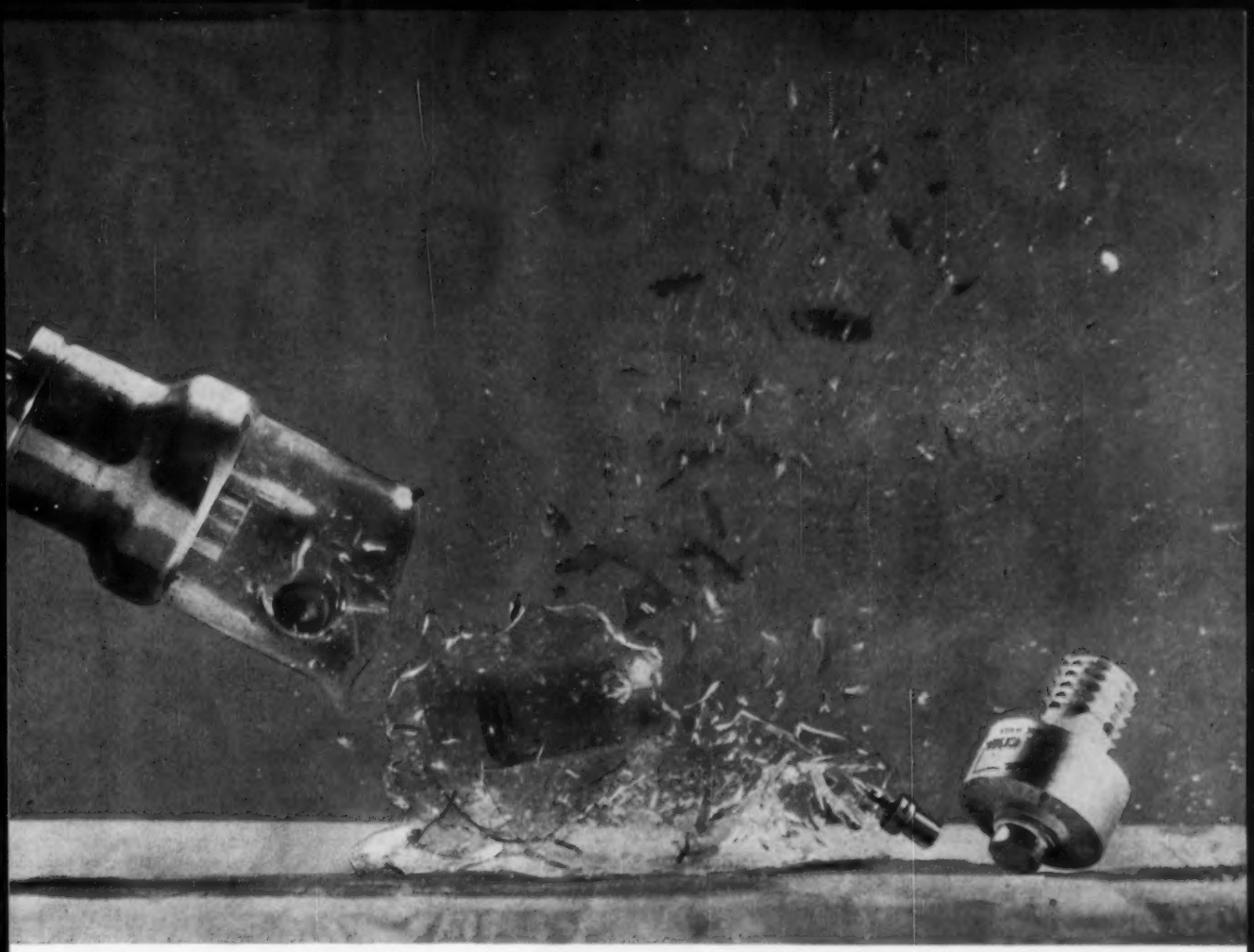


Surviving Impact is an Eimac Ceramic Tube Extra

Aeronautical electronics demands extras from vacuum tubes. Among them is the ability to withstand heavy impact without impairing electrical characteristics. The photograph dramatically shows what happens to a 250 watt glass envelope tube and an Eimac 300 watt ceramic tube when both are dropped from a height of seven feet. The ceramic tube "took it."

Other advantages of Eimac ceramic tubes are: resistance to damage by vibration and temperature; smaller size without sacrificing power; ability to undergo optimum processing techniques that lead to tube reliability and longevity.

The small Eimac ceramic 4CX300A, shown above, will withstand 50G shocks of 11 millisecond duration. It will operate in airborne or ground station service at full ratings up to 500mc.

In its new line of ceramic tubes, Eimac has the answer for the aeronautical engineer who needs a tube that will deliver full output under extreme environment.

For further information, consult our Application Engineering Department.

EITEL-McCULLOUGH, INC.
SAN BRUNO · CALIFORNIA

Eimac First **with Ceramic Tubes that can take it**

Eimac

4CX300A MAXIMUM RATINGS TO 500MC

	FM	AM	SSB
D-C Plate Voltage	2000	1500	2000
D-C Screen Voltage	300	300	400
D-C Grid Voltage	—250	—250	—
D-C Plate Amperes	.250	.200	.250

	FM	AM	SSB
Plate Dissipation, watts	300	200	300
Screen Dissipation, watts	12	12	12
Grid Dissipation, watts	2	2	2

ONE
makes
FOUR
FOUR distinct divisions in one steel company, inter-related, specialists in their own field of endeavor and singly managed.
Some clients take advantage of all four, others one or more.
CONCRETE REINFORCING STEEL INSTITUTE
CRSI
AISC
STEEL PLATE FABRICATORS ASSOCIATION
SOUTHWARD STEEL

STRUCTURAL & REINFORCING DIVISION Fabricated structural and reinforcing steel for buildings, bridges, and industrial structures.

TOWER & SUBSTATION DIVISION Substation structures and transmission towers for the electrical and communications industry. (sold and shipped competitively everywhere).

PLATE DIVISION Fabricated plate products for the oil, chemical and processing industries.

STEEL WAREHOUSE DIVISION Distributors of carbon steel and construction products.

for over 40 years

FLINT STEEL CORPORATION

TULSA . . . MEMPHIS

(Continued from page 36A)

New Products

Aluminum Feed-In Duct. A line of totally enclosed aluminum feed-in duct, Underwriters' Laboratories approved, that does not require derating has been introduced by the Square D Company. This totally enclosed feature is accomplished by separating and enclosing the aluminum bus bars in solid sheets of insulating material. This not only reduces the cross action but also results in an extremely low voltage drop and a high short-circuit strength that equals or exceeds National Electrical Manufacturers Association (NEMA) standards on all ratings. The duct is available in all standard ratings from 600 to 4,000 amperes; two, three, and four pole. For further information, write to Square D Company, 6060 Rivard St., Detroit 11, Mich.

X-ray Fluorographic Recording Camera. This 70-mm camera made espcially for X-ray and fluorographic recording is announced by Photographic Products Inc., manufacturers of electric recording cameras and precision timing instruments. Called the Beattie Fluorotron Camera Model-*R*, it features automatic, electrical operation throughout, and is compact, lightweight, and streamlined in appearance. It operates on 115 volts a-c, 50-60 cycles. For more complete information and prices of the Beattie Fluorotron Camera Model-*R*, write direct to the manufacturer, Photographic Products Inc., 1000 No. Olive St., Anaheim, Calif.

Low-Priced Gauge Blocks. The introduction of low-priced gauge blocks adds new meaning to gauge makers' tolerances. Any gauge must be 10 times as accurate as the tolerance of the part being measured. An efficient way consistently to hold tolerances is to utilize gauge blocks directly as working gauges and, thereby, eliminating error-producing extra operations. The Shop-Blocks, produced by The DoAll Company, now make this feasible for all shops. These low-priced gauge blocks may be combined with the Micro-Step holders in order to form functional working gauges. For further information write The DoAll Company, 254 North Laurel Ave., Des Plaines, Ill.

Cable in Tape Form. The introduction by Tape Cable Corporation, 790 Linden Ave., Rochester 10, New York, of a flat, multi conductor, ribbon-like electrical cable, known as Tape Cable (*registered trade mark*) has opened up new concepts in the field of electrical design. The cable is a flexible film in which are imbedded flat copper conductors only 0.0015 inch thick. The conductors are parallel, accurately positioned, and are surrounded by carefully controlled transparent polyester insulation. This results in a cable having minimum cross sectional area, minimum interconductor capacitance, high tear strength, high flex life, and high resistance

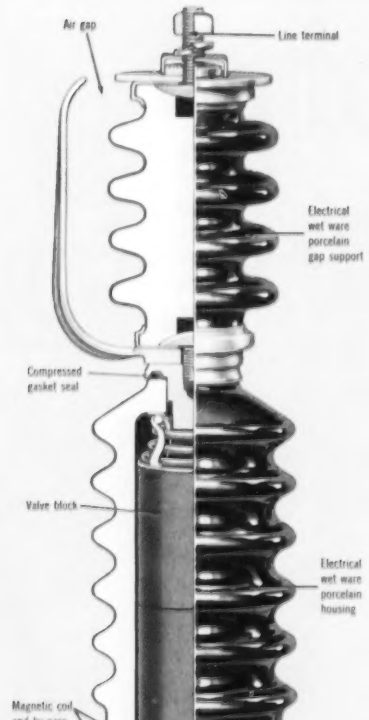
(Continued on page 46A)

A COMPLETELY NEW Distribution Lightning Arrester ... Unlike Anything In Its Field ... Is Described on the Next Page

A New Approach to Distribution Arresters

Dynagap element of Thorex distribution lightning arrester. This identical assembly is used in all grades of new Thorex arresters, including heavy-duty station types for 230 kv and higher service. This imparts a degree of ruggedness entirely new in the distribution field.

Thorex Dynagap First to Use Rugged Station Type Essential Parts for Distribution Service



Operating parts of a new Thorex Dynagap distribution arrester. This model is equipped with an external series air gap. Another similar model uses an internal series gap and an automatic ground lead isolator.

Invention of the extremely small and efficient Dynagap for Thorex high-voltage lightning arresters has opened the way to further development -- an entirely new distribution arrester with unheard-of features.

Never before have identical vital parts been interchangeable between maximum-duty station type and distribution type arresters. The compact new Thorex Dynagap has made this possible. It brings to the distribution field both principles and performance of an entirely new order.

Because of its inherently rugged station type elements, this arrester is exceptionally effective in dealing with the heavy lightning discharges typical of un-shielded distribution circuits. This is coupled with complete freedom from the influence of fault current magnitude at the arrester location. Its 60-cycle follow current interrupting ability is not limited by either maximum or minimum system fault currents, thus giving it a universal field of application. It may be used interchangeably at high power locations or those of low power and high lightning incidence.

Influence of station type design goes beyond the use of the same essential series gap parts. Performance of any arrester, regardless of type, is highly dependent upon the permanent exclusion of moisture. Sealing practices common to the heavier-duty Thorex arrester models are used in the new distribution series. Maximum gasket efficiency is assured by the same system of spring-pressure-follow sealing used with such excellent results in larger Thorex models.

As will be explained briefly on the next page, the radically altered ratio of power-follow current limitation between the series gap element and valve blocks, by action of the new Dynagap, opens-up a fruitful field of technical improvement. Many important functions can now be "tailored" to the special requirements of distribution service. This is one of the greatest advancements ever made in arrester development.

You will hear and read a lot more about this striking development in coming months. For still better knowledge, however, gained on your own terms, install a few sets right away. Pick spots where arresters never could -- or never have -- worked before. Then you will know, firsthand, the real importance of the new Dynagap.

OHIO BRASS COMPANY • MANSFIELD, OHIO

Ohio Brass

Dynagap Applies Advanced Principles to Lightning Arrester Operation

Ingenious Gap Performs Major Portion of Valve Action—Permits Radical Valve Block Improvements

After lightning action of a valve type arrester, 60-cycle follow current continues to flow. This is extinguished by the combined current-limiting function of the series gaps and valve blocks. Until recently, the blocks supplied 98 to 99 per cent of the necessary resistance.

Magnetic arc blow-out, pioneered in 1953 by the Thorex high voltage arrester, added a degree of "valve action" to the gap performance. By stretching and cooling the arc, high arc resistance was built up in the gap. This permitted the gap to assume about 10 per cent of the total resistance in the arrester circuit.

When valve blocks supplied 98 to 99 per cent of the required resistance, this predominant duty ruled their composition. It forced compromises with other recognized modern necessities -- primarily, high durability under severe long duration surge current discharges of natural or system origin. Improvements introduced by Thorex arresters in 1953 materially relieved these restrictions on valve block composition and resulted in strikingly better performance.

Observing these facts, O-B development engineers were fascinated with the possibilities of a more radical alteration of the gap-to-block resistance ratio. After three years of intensive research, the Dynagap has evolved. Originally it was designed to meet the pressing demands of heavy duty, high voltage station service, but its drastically reduced dimensions adapted it to distribution application where it retains many of its basic station type characteristics, and imparts unheard-of performance to distribution grades.

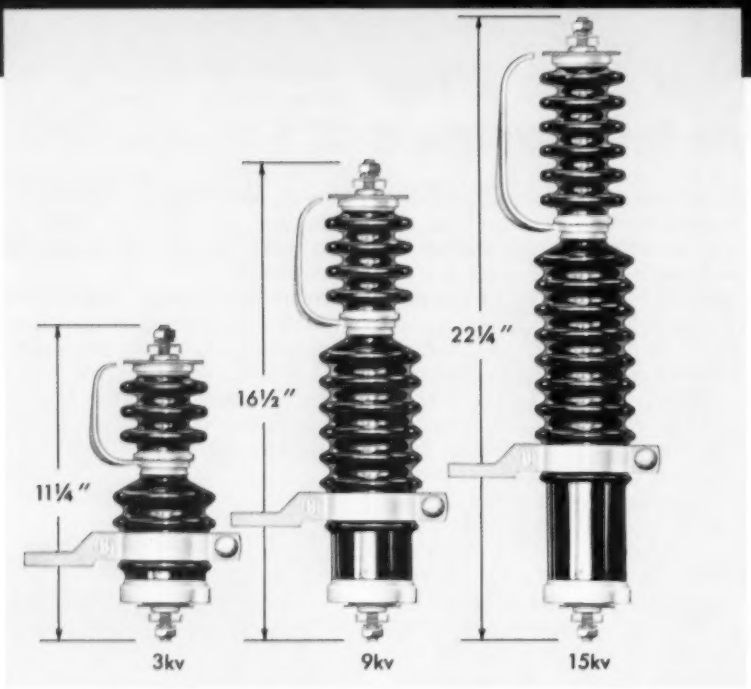
Applied to new Thorex distribution arresters, the Dynagap supplies 30 to 40 per cent of power follow limiting resistance. As a result, many restrictions have been removed from valve block development, and new blocks can be "tailored" to the specific requirements of distribution service -- an advantage never before possible. The result is an entirely new conception of distribution arrester -- an entirely new order of balanced design and performance.

Never before has a distribution lightning arrester used the identical essential parts of high voltage station type models. And, never before, have such outstanding qualities been offered in the distribution field.

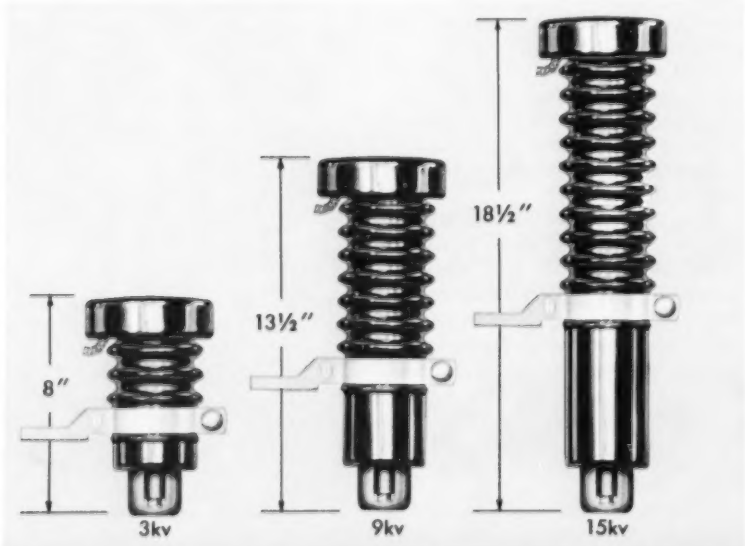
Opening the Dynagap structure reveals a series of thin Mycalex plates, mechanically interlocked for stability, compactness, and arc restriction. Each plate contains one gap electrode on either side, riveted through for series connection. By a system of precise indexing, these electrodes are positioned for proper gap spacing when the stack is assembled. The structure shown is for an arrester operating at 13.8 kv. It has 13 plates and 12 sets of gaps, and is capable of stretching the arc 33 linear inches. It is this great stretching action that builds-up high arc resistance and contributes an important share to power-follow current limitation; simultaneously relieving the valve blocks of this portion of duty.

Operating parts of the Dynagap. Magnetic coils above and below the gap element, when energized, drive the follow current arc away from the initial spark gap and into the arc control chambers. In this way the arc is stretched 140 times its original spark gap length and high resistance is built-up. Connected in parallel with the coils, in their centers, are by-pass resistors. These are small discs of valve block material having highly non-linear resistance. When lightning impulse occurs, the high inductive impedance of the coils and the low resistance of the blocks at elevated voltage result in passing this discharge through the resistors, across the close setting of the gaps, through the main valve blocks, and to ground with resulting exceptionally low IR discharge voltage. Follow-current at 60-cycle line voltage is presented with a high-resistance state in the non-linear by-pass resistors, but readily passes through the coils. This creates a strong magnetic field that drives the arc, builds high arc resistance, and leads to extinguishment.

New Dynagap Permits Size Reductions Down to Half That of Other Distribution Arresters



Typical Thorex Dynagap distribution lightning arresters. Line-to-ground ratings of both types graduate from 1 to 18 kv. One group is typified by an external air gap in series with the arrester in order to follow distribution practice of having the arrester completely disconnected from the circuit while not operating. The second group is likewise equipped with a line lead and a series gap contained within the arrester housing. This type also features an automatic ground lead isolator that frees the arrester from the circuit in the event of some damaging accidental overload. Since such conditions always result in instantaneous high heat, this is used to discharge a small explosive rivet that blows the ground connection clear.



● Dynagap distribution lightning arresters set a new standard for reduced size--a quality greatly welcomed by many users. Compared to any other arrester now manufactured, types above 3 kv rating range from 10 to over 50 per cent smaller. Greatest reductions are in higher voltage ratings where dimensions are more of a factor.

While radically miniaturized, the Dynagap distribution arrester uses vital operating parts interchangeable with highest-duty station grade Thorex models. Such a combination of reduced size with other unheard-of essential features makes this new arrester unique in the distribution field.

Among other advantages, the new Thorex distribution types -- with all their advanced features are available at no price premium.

Start now with your first installations of Thorex Dynagap type DV arresters on your distribution circuits.

OHIO BRASS COMPANY
MANSFIELD, OHIO

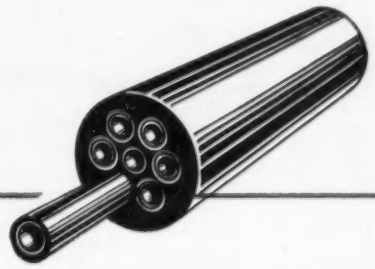
Ohio Brass

4776-H

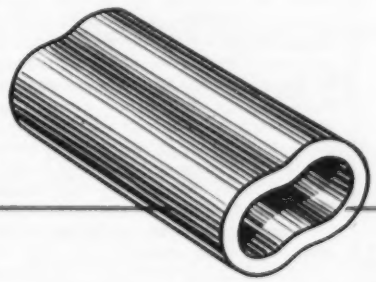
DEPENDABLE

TUBULAR PRODUCTS FOR THE ELECTRICAL INDUSTRY

This is Wolverine Trufin®—the integrally finned condenser tube that transfers more BTU's per foot of tube . . . is ideal for use in oil cooled transformers.



Ideal for transmission purposes is Wolverine small diameter tubing. This rigidly quality controlled product is available in copper, copper-base alloys and aluminum.



Typical of Wolverine's fabrication techniques is this electrical connector which is available in both copper and aluminum.

For completely dependable tubing and tubular-shaped components your best bet is to work with a company that has made dependability a word to live by.

Wolverine Tube emphasizes the quality of the tubing and tubular-shaped parts it produces for electrical customers. All products are manufactured under a program of Tubemanship: statistical quality control, constant research, sound engineering and years of experience—skillfully blended together to insure Wolverine customers of top flight products—all the time.

Wolverine provides electrical manufacturers with both finned and prime surface condenser tube for transformer oil coolers. And for transmission purposes, Wolverine furnishes small diameter tubing in copper, copper-base alloy and aluminum. Wolverine's fabrication facilities include equipment for finning, spinning, bending, beading, coiling, flaring, expanding and extruding.

Next time you order tubing or tubular-shaped products, remember Wolverine Tube and its Tubemanship program. It can be your open door to new concepts of quality. For more information write for our General Products Catalog.

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WOLVERINE TUBE DIVISION
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CANADA VULCANIZER AND EQUIPMENT COMPANY LIMITED

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Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes

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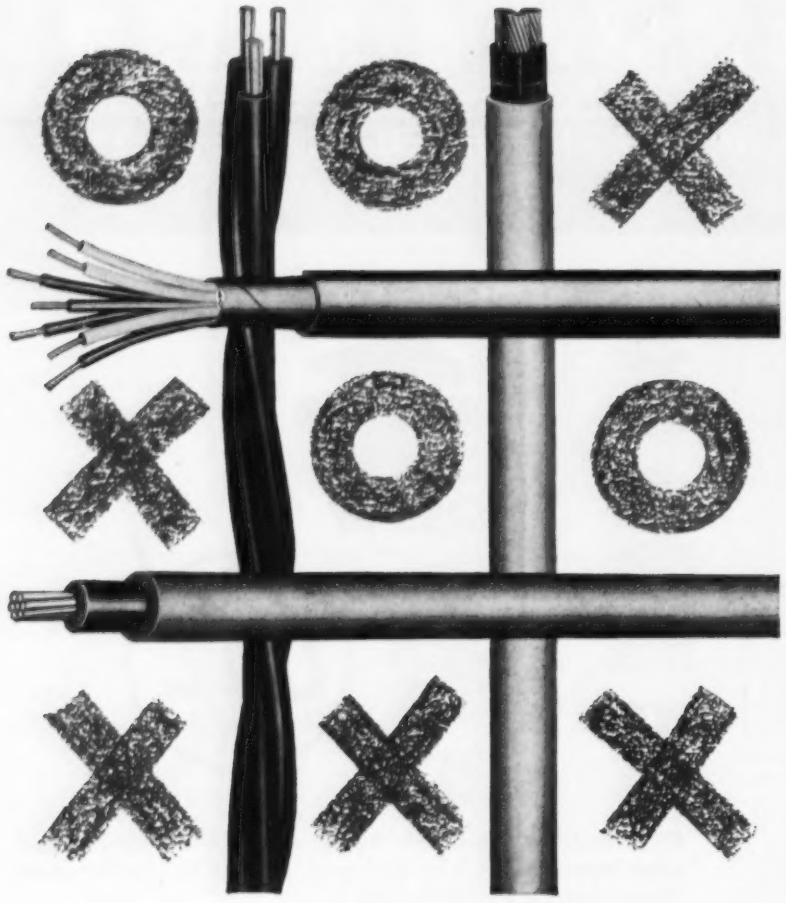
SALES OFFICES IN PRINCIPAL CITIES.

EXPORT DEPARTMENT, 11 EAST 40TH STREET, NEW YORK 16, NEW YORK

Wolverine Trufin is available in Canada through the Unifin Tube Co., London, Ontario.



Beat high cable costs in 3 easy moves...

One, make sure that the cables you specify are designed and made to offer maximum service life with minimum maintenance under the toughest conditions. Collyer Cables will more than meet your highest standards. **Two,** save yourself time and trouble by ordering your complete cable requirements from one dependable source of supply. Collyer Engineers can match your exact specifications quickly and easily. **Three,** act now and get the first-hand facts on Collyer Cables. Write, wire or phone **Collyer Insulated Wire Co., 245 Roosevelt Ave., Pawtucket, R. I.**

LIVE BETTER ELECTRICALLY

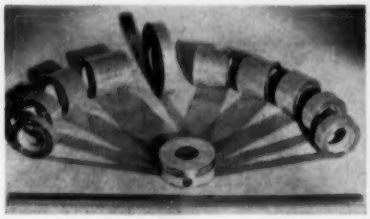
Collyer

Power Cables • Control Cables • Switchboard Wires • Service Wires • Series Lighting Cables • Building Wires

(*Continued from page 40A*)

New Products

to chemical attack. Conductors in standard Tape Cable have 0.100 inch center-to-center spacing in accordance with the recommended RETMA (EIA) grid pattern for printed wiring. Nine standard sizes have been established, having 9, 14, 17, 21, 27, 30, 36, 40, or 50 conductors. The most striking electrical characteristic of



Tape Cable is its low interconductor capacitance. It is ideal for high frequency applications. It is expected that Tape Cable will be widely used in applications where weight and space are critical, such as aircraft, missiles, portable, and mobile equipment. Its widest use is expected in telephone equipment and computers and other electronic equipment where multiple electrical interconnections must be made with a minimum of labor and expense. Tape Cable readily lends itself to automation techniques.

Transformer. Incoming line, transformer, and outgoing feeder are compactly arranged in a new dry-type transformer for in-plant distribution of power. The unit is 63½ inches high, 74 inches long, and 38 inches deep. It is shipped, handled, and installed in one piece. Operation and routine servicing can be done from the front of the unit. No vault is required. Details and dimension prints are available from The Standard Transformer Company, Warren, Ohio.

New Single-Phase Watt-hour. General Electric has announced a single-phase watt-hour meter with a revolutionary stator design permitting "on-line" accuracy up to 200 amperes. Called the *I-60*, it is a 30-ampere, 240-volt, 3-wire single-phase model, with an overload capacity of 667%. The meter was developed to provide a meter for all loads up to 200 amperes, equal in performance or better than any existing single-phase meter, and at a cost no greater than available Class 100 types. In the new stator, the conventional combined voltage and current electromagnet is replaced with a pair of magnetically isolated electromagnets, one for voltage and one for current. Like the *I-50* family of watt-hour meters, the *I-60* features magnetic suspension of the rotor with all the attendant benefits, including elimination of bearing maintenance. The *I-60* meter, like its predecessors, will operate accurately over the wide range of ambient temperatures encountered on meter installations. For further information contact the company at Schenectady 5, N.Y.

(*Continued on page 58A*)

NATIONAL BRUSHES HELP SOLVE AUTOMATION'S BIGGEST PROBLEM:

"adjustable speeds"

Economical M-G sets and D-C motors — using "National" brushes — supply the highly controllable power vital to self-correcting automated equipment.

Compact motor-generator unit combines A-C savings with D-C pin-point control

Why these NATIONAL brush grades are best for automation:

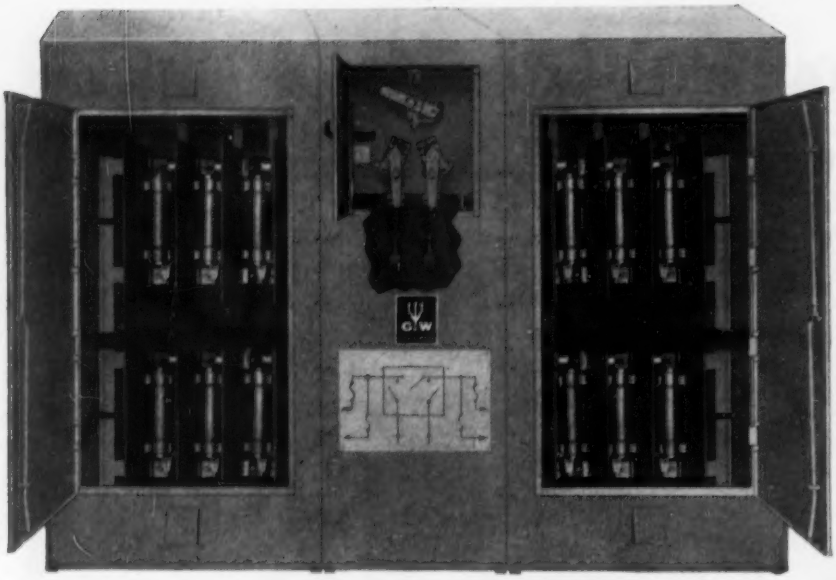
SA-45 SA-35 N-4

- Superior commutating ability over a wide speed range
- Brush uniformity assures consistent machine performance
- Superior brush operation reduces expensive down-time and equipment maintenance

See your "National" Brush Man when you're selecting carbon brushes. He has a brush for every need, plus the experience and backing to help you assure continuous good performance.

UNION CARBIDE

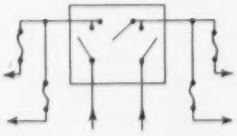
The terms "National", "Union Carbide" and the Silver Colored Cable Strand are registered trade-marks of Union Carbide Corporation
NATIONAL CARBON COMPANY • Division of Union Carbide Corporation • 30 East 42nd Street, New York 17, N. Y.
Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. *In Canada:* Union Carbide Canada Limited, Toronto



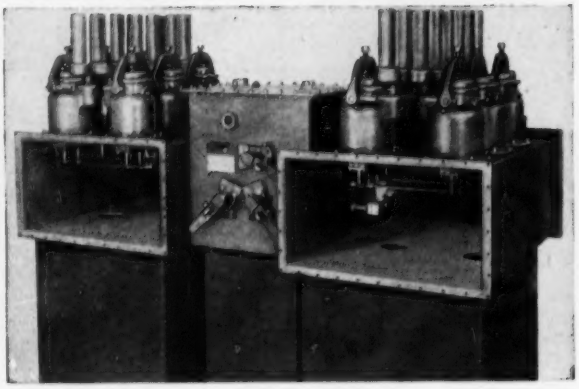
Type "SCRA" unit, 3 pole, 5000 volts, 400 ampere, 4-way oil switch with 4 sets of high interrupting capacity power fuses. Similar units are available in 15 Kv. and higher voltage ratings.

FLEXIBILITY for 2 Feeds & 4 Loads

— safely and economically provided by G & W load break oil switches combined with power fuses or with oil fuse cutouts.



The schematic diagram above applies to either combination unit illustrated. The Type "RA" load break oil switch has three sets of manually operated links. Normally, the upper set of links are open and two loads are supplied from each feeder separately. By opening either set of lower links and closing the upper links, all four loads can be supplied by either feeder.



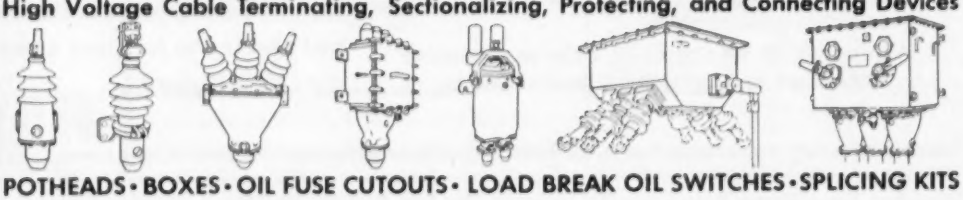
Type "FCRA" unit, 3 pole, 5000 volts, 400 ampere, 4-way oil switch with 4 sets of "FC42" oil fuse cutouts, 5000 volts, 200 amperes, gang operated.

Get in touch with us or our nearest representative for information on combination Fuse-Switch units for your high voltage distribution centers.

G & W ELECTRIC SPECIALTY COMPANY
3500 W. 127th ST., BLUE ISLAND, ILLINOIS

CD571 Representatives in many cities of U. S. A., N. & S. America Canadian Mfr. – Powerlite Devices, Ltd., Toronto, Montreal & Vancouver

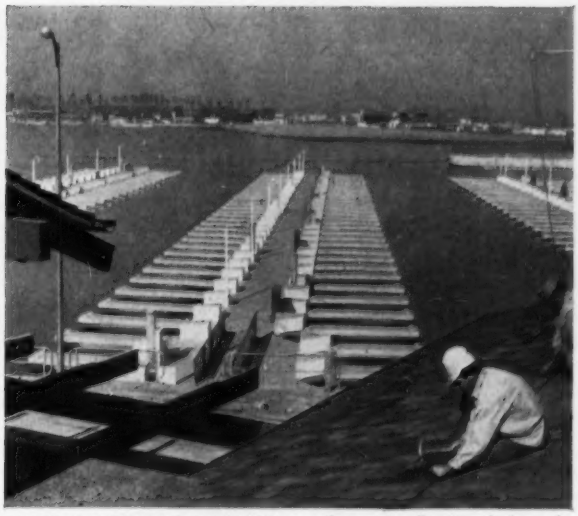
High Voltage Cable Terminating, Sectionalizing, Protecting, and Connecting Devices



POTHEADS • BOXES • OIL FUSE CUTOUTS • LOAD BREAK OIL SWITCHES • SPLICING KITS

ALAMITOS BAY MARINA BASIN #1, built by the City of Long Beach, Calif: S. E. Vickers, city manager; J. D. Gilkerson, city engineer; B. E. McCune, deputy city engineer; Thomas G. Marchese, project engineer. Engineers: Moffatt & Nichol Inc., Long Beach. Electrical contractor: Ets-Hokin & Galvan, Wilmington, Calif. Everdur Conduit furnished by General Electric Supply Company, Long Beach, Calif.

Over two miles of Everdur Conduit guards electric service at new Long Beach, Calif., marina unit, serving 342 boats



EVERDUR ELECTRICAL CONDUIT is installed under floating docks, only inches above the water. Plug-in electrical outlets are located at lockers by each slip and on lighting standards. *Below:* Everdur Electrical Conduit is available in two wall thicknesses—R. C. and E. M. T.

PHOTOS COURTESY INDEPENDENT-PRESS-TELEGRAM, LONG BEACH, CALIF.

The City of Long Beach, Calif., is in the process of transforming its Alamitos Bay area from tide flats and a massive mosquito factory into one of the finest small boat harbors in the world.

The first boat basin and marina unit, which can accommodate 342 boats, is now complete. The floating docks are well lighted and at each slip, boat owners have plug-in electric service and a fresh water tap. All electrical wiring from the shore out is protected by Everdur® Electrical Conduit – well over 11,000 feet, ranging from ½″ nominal size to 3″. In addition, all fittings and boxes are of Everdur.

Everdur Electrical Conduit – made from one of Anaconda's copper-silicon alloys—never rusts and offers high resistance to other types of corrosion. It provides dependable year-after-year protection wherever water and corrosive atmospheres are a problem – or where conduit must be buried or embedded in concrete. Everdur is also tough – it stands up under movement and vibration.

For detailed information, write: The American Brass Company, Buffalo Division, Buffalo 5, N. Y. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

07109

EVERDUR
ELECTRICAL CONDUIT

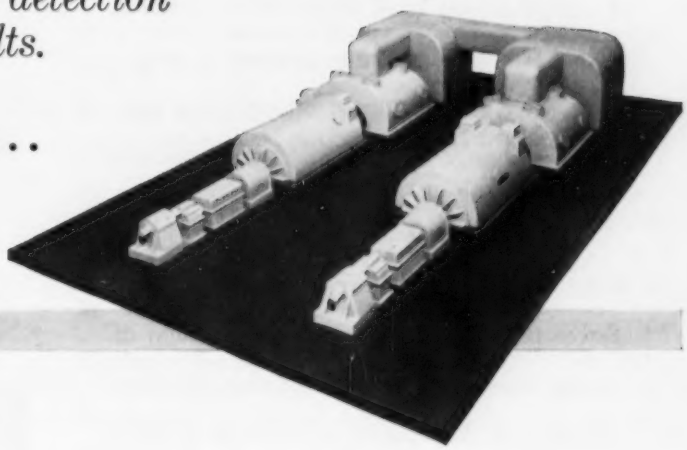
an ANACONDA® product
made by The American Brass Company

CORROSION RESISTANT • STRONG • NONMAGNETIC • WORKABLE • WELDABLE

RELIABLE

GENERATOR RELAY BACK-UP PROTECTION

COV unit simplifies detection of less-than-load faults. Current unit is voltage controlled... not restrained



Voltage controlled by a high-speed cylinder unit, the new Westinghouse COV relay for detection of generator bus or transmission line less-than-load faults, achieves reliability and speed without intricate voltage calculations.

The overcurrent unit is a low-burden-type Westinghouse CO overcurrent relay. The voltage unit is a high-speed cylinder design, with adjustable pickup from 80 to 100 volts a-c. Both are contained in a single Flexitest* universal case and can be independently set.

Fault currents are accompanied by voltage reduction which allows the voltage unit to reset, closing its contact to complete the CO operating coil circuit. System swings and heavy overloads will not cause unwanted relay operation.

Less-than-maximum load setting of the overcurrent unit is necessary to provide reliable protection because of the narrow margin between load and generator fault current, due to the decay of fault current shortly after the fault occurs.

The new COV is available in several operating-time characteristics, assuring selective coordination with adjacent relays; Complete details are available from your Westinghouse salesman or relay specialist. Or you may write direct to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-40497

*Trade-Mark

YOU CAN BE SURE...IF IT'S

Westinghouse

Improved-quality extrusions at faster rates with

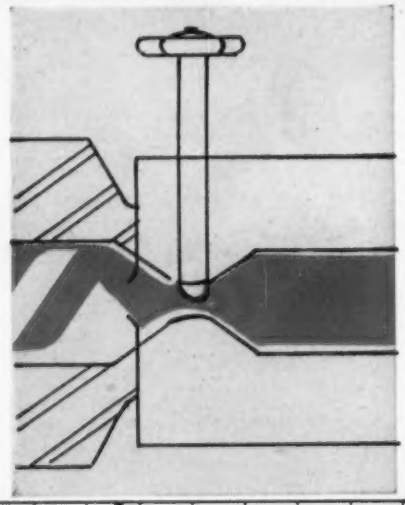
new "controlled pressure" extrusion technique

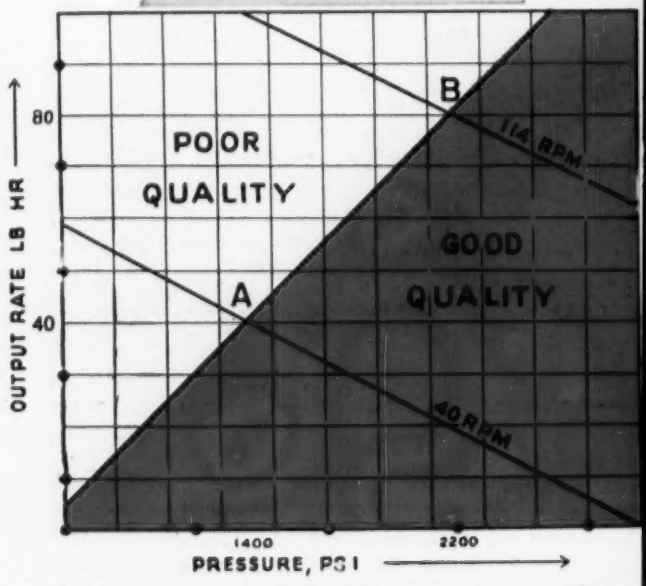
Experiments have shown that extrusion quality is related to three primary factors—pressure, resin temperature, and extrusion rate. A change in any one of these factors affects one or both of the others.

Now, Bakelite Company Laboratories have developed an efficient, accurate method of controlling pressure during the extrusion operation. Essentially, it employs a valve between the extruder head and the die, together with a pressure gauge and an immersion thermocouple in the head, or between the head and the valve.

This process provides a continuous method of control. Proper manipulation of pressure and screw speed results in better temperature control and improved resin homogeneity, better mixing characteristics and an improved product at increased output.

The development of this controlled-pressure (valve) extrusion by Bakelite Company permits operation of all extruders at their maximum capacity while maintaining highest quality.



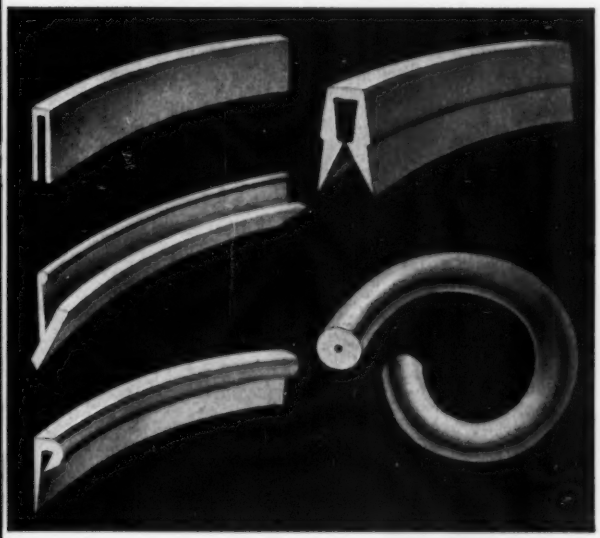


The above graph on a typical sample run gives dramatic evidence of the effect of the controlled pressure (valve) extrusion technique on output. Without the valve, the highest usable screw speed, giving commercially acceptable quality, was 40 rpm. This resulted in an output rate of 40 pounds per hour or 100 feet per minute (Point A). When the streamlined controlled pressure valve was used, the screw speed could be increased to 114 rpm, *DOUBLING* the acceptable-quality production rate (Point B).

The values used in the above figure are the result of one sample test run under a typical set of extrusion conditions and should not be applied empirically to other extrusion conditions. Conditions used in this test were as follows: two inch extruder using a dry blend electrical compound based on QYRS extruded on number 14 wire with a wall thickness of 1/32 inch. Improved extrusion results, similar to those shown for wire and cable, may be expected for other applications.

new BAKELITE BRAND dry-blend Vinyl Resin QYRS

Controlled pressure (valve) extrusion permits the extrusion of dry-blend resin comparable in quality to the extrusion of hot-flux materials. When used with BAKELITE Brand Vinyl QYRS, it results in a superior product with improved finish, reduced roughness, and minimum "fisheyes".



QYRS is desirable for preblend formulations used in both electrical and non-electrical applications. It is particularly suitable for building wire, flexible cord, appliance wire, telephone wire, power cable, and such contour extruded items as garden hose, welting, and belting.

Advantages of QYRS include the following:

- **High bulk density** of 30-35 lbs./sq. ft., permitting larger tonnage output rates from a given size blender.
- **High specific viscosity** of 0.205 to 0.220, resulting in improved physical properties, such as strength.
- **More uniform particle size,** ensuring maximum extrusion rate, minimum dusting, and proper dispersion of plasticizer with resin.
- **Batch-to-batch uniformity,** assuring uniform extrusions.
- **Faster dry blending time,** based on tests that prove QYRS will dry blend 10-15% faster than conventional resins while still maintaining excellent dispersion of ingredients.
- **Utilization of present cycle,** so that fabricators can use the same blending cycle as presently employed with other dry-blending resins.
- **Adaptability to a shorter cycle** as a result of faster plasticizer absorption.

For further information on the controlled pressure (valve) extrusion method and the new BAKELITE Brand dry-blend vinyl resin QYRS, write Dept. YZ-55.

BAKELITE
BRAND
PLASTICS

UNION CARBIDE

BAKELITE COMPANY, *Division of Union Carbide Corporation,* 30 East 42nd Street, New York 17, N. Y.

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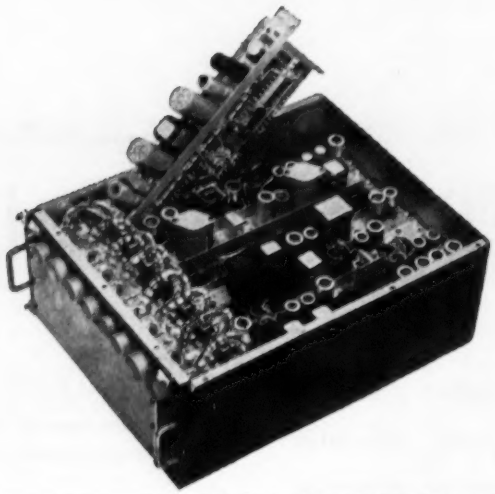
Problem:



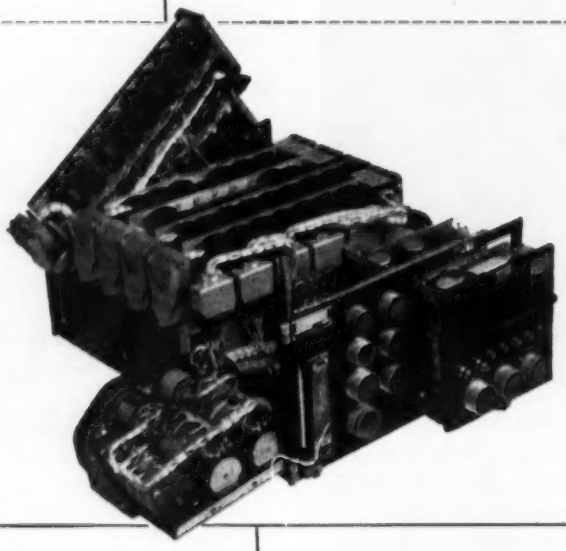
Redesign of an airborne analog computer to perform additional functions called for 20 per cent more parts— with no over-all increase in size, or change in form. At the same time, a high degree of reliability had to be maintained.

APPROACH TO RELIABILITY

Advanced radar fire control systems for military aircraft demand the highest degree of reliability under severe restrictions. These include quantity manufacturability, minimum size and weight, protection from shock and heat, serviceability, and exacting performance.

At Hughes, one objective of equipment design engineers is to maintain consistent essential performance of the systems while steadily improving reliability. Following is an example of accomplishment by Hughes engineers in this specialized area:

Solution:

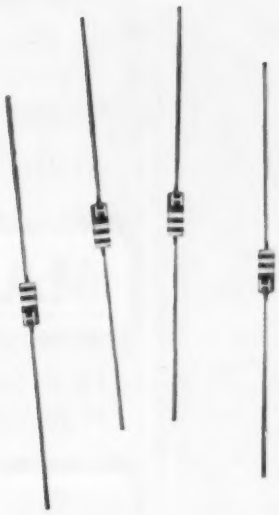


By use of improved components, unique packaging techniques, and thorough environmental testing, Hughes design engineers were able to meet specifications and improve reliability as well. Result was that the new computer operated at mean internal temperatures in excess of 120°C and withstood shocks of 50 g's— as against 85°C and 30 g's for the original unit.

ENGINEERS experienced in the fields of product design, electronics packaging, miniaturization and component reliability will find outlets for their abilities in new advanced packaging and reliability problems.

HUGHES

RESEARCH AND DEVELOPMENT LABORATORIES
SCIENTIFIC STAFF RELATIONS
Hughes Aircraft Company, Culver City, California



Hughes

Quick Recovery

Silicon

Junction

Diodes

FASTER THAN GERMANIUM COMPUTER DEVICES

...and able to withstand high voltages at high temperatures, these quick recovery silicons are particularly useful in circuits where germanium once provided the only possibility. Unlike germanium, breakdown voltages for the silicons *increase* with temperature, thereby removing the danger of failure should temperatures rise to unexpected levels. This kind of ruggedness together with increased speed identify the diodes as ideal when the demand for reliability is greatest.

Perhaps one of the IN620 series will be just right for your particular application; if not, there will undoubtedly be a Hughes germanium or silicon diode that is. For a call from one of our field sales engineers or for additional information about our quick recovery silicon diodes, please write:

SPECIFICATIONS	
WIV @ 0.1mA	up to 200V
Forward Voltage @ 4mA	less than 1.5V
Recovery (modified IBM "Y" test)	400K ohms (min.) in one μsec. when switched from 50mA forward to −35V reverse.
Reverse Current @ 25°C	as low as 1μA @ −175V
Reverse Current @ 100°C	as low as 100μA @ −175V
Operating Temperature Range	−80°C to +150°C

PHYSICAL CONFIGURATION. All types are packaged in the famous glass body, created at Hughes to provide absolute protection from moisture penetration and contamination. Body length: 0.265 inch maximum. Body diameter: 0.105 inch maximum.

Types now available IN625 through IN629

SEMICONDUCTOR DIVISION • HUGHES PRODUCTS *International Airport Station, Los Angeles 45, California*

Creating a new world with ELECTRONICS

HUGHES SEMICONDUCTORS

HUGHES PRODUCTS

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RUGGED VERSATILE ELECTRONIC GALVO

20 uua or 0.2 uv per division sensitivity

Solve your bridge balance and low-level DC measurement problems with this sensitive, rugged, and versatile combination DC null detector, micro-micro-ammeter, microvoltmeter, and microvolt level DC amplifer.

Current sensitivity of the Model 204A is 20 times greater than high quality, mechanical current galvanometers. As a voltage galvanometer, its extremely high power sensitivity makes it superior to moving coil instruments.

Ideal for production testing, low level DC amplification to extend the range of recording instruments, or as a direct reading indicator for strain gage, thermocouple and other current or voltage measurements in industry or laboratory.

SPECIFICATIONS

- 10uv to 10 volts or 0.001 ua to 1 milliamp full scale in 7 ranges
- All transistorized — Rugged — Insensitive to shock, microphonics, mounting position
- Withstands extreme overloads with no zero offset
- Floating input — 10,000 ohm fixed input resistance — No restrictions on source resistance.
- 10^{-14} full scale power sensitivity
- Use as stable DC amplifier with 1 volt at 1 milliamp output
- Less than 2 uv drift, less than 1 uv P-P noise

Representatives Nationwide.
Ask for demonstration today or write for detailed literature.

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8725 KEARNY VILLA RD.
SAN DIEGO 11, CALIFORNIA

Power Supply for Resistance Welding Machines
(April 1952)

AIEE Special Publication S-45 is a report of the AIEE Subcommittee on Power Supply for Resistance Welding Machines. Recognizing that the installation and use of any resistance welding process vitally concerns not only the industrialist requiring the process but also the welding machine manufacturer and the utility supplying the electric power as well, the committee has in this report brought together much pertinent data from the knowledge, literature, and experience in all these fields.

This publication supersedes the AIEE reports of the same title presented in 1940-1. The new work is required by developments in welding machines, new processes, better analysis of certain phenomena (such as measurement of instantaneous loads, and interference between welders), and a clearer understanding of the whole problem of power supply for resistance welders.

This report is not intended to be a complete solution of all welding problems, but should direct attention to the special electrical features involved so that a full analysis developed for a welding project can be readily understood and utilized by manager, master mechanic, and electrical engineer.

Copies are available for the price of $1.00 (no discounts permitted). Address:

Order Department
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New York 18, N. Y.

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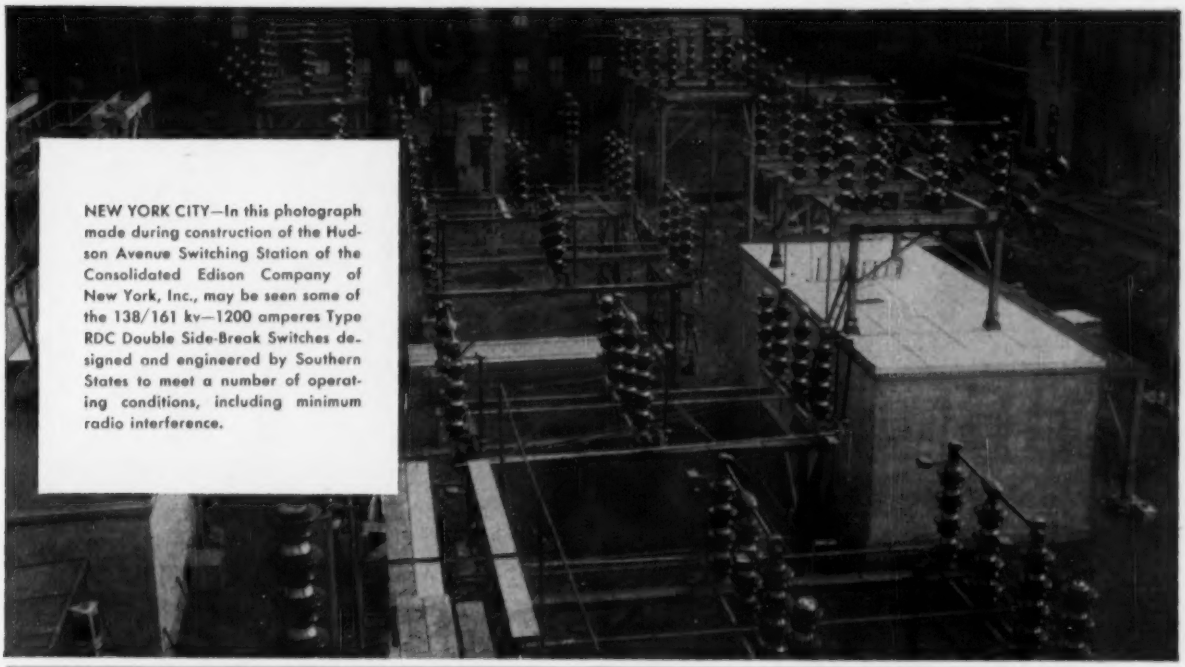
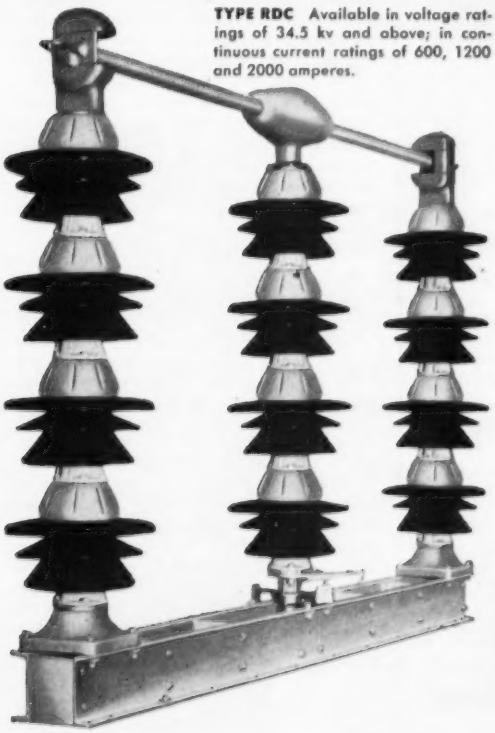
Six dollars for both parts, plus postage, will be paid for copies returned.



NEW YORK CITY—In this photograph made during construction of the Hudson Avenue Switching Station of the Consolidated Edison Company of New York, Inc., may be seen some of the 138/161 kv—1200 amperes Type RDC Double Side-Break Switches designed and engineered by Southern States to meet a number of operating conditions, including minimum radio interference.

Consolidated Edison Picks Type RDC Switches For its Hudson Avenue Switching Station



TYPE RDC Available in voltage ratings of 34.5 kv and above; in continuous current ratings of 600, 1200 and 2000 amperes.

The newest member of Southern States' complete line of air break switches was chosen by Consolidated Edison for its recently completed Hudson Avenue Switching Station.

The Type RDC has an RIV of less than 500 microvolts, a primary requirement for this station located in Brooklyn, New York.

There are many other advantages of this double side-break switch, including:

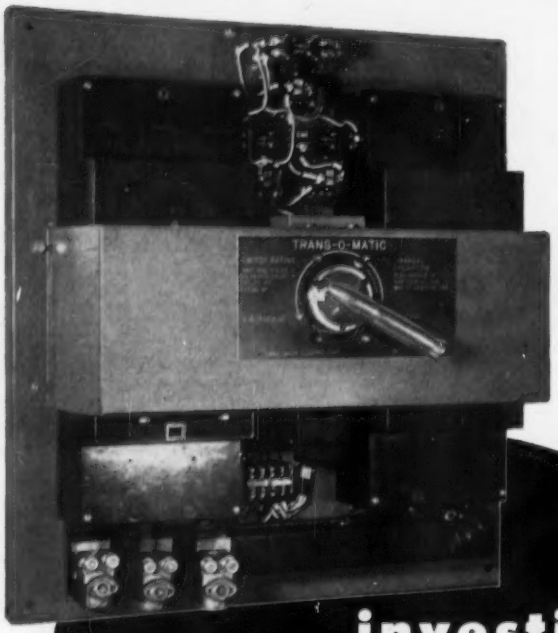
- **High momentary current rating**
- **Streamlined, corona-suppressing contours**
- **Minimum number of current interchange points**
- **Shuntless design**
- **Wide angle blade rotation**
- **AMPLITACT® silver-to-copper contacts**
- **Shielded mechanisms—complete icing protection**
- **Greaseless, non-corroding ball bearings**
- **Switch blade is one continuous member**

Your Southern States representative will be glad to give you more information about this new switch.

SOUTHERN STATES
EQUIPMENT CORP.
HAMPTON, GEORGIA

IN CANADA: Dominion Cutout Co., Ltd., Toronto

if YOU'RE responsible for POWER CONTINUITY



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PARTIAL VOLTAGE FAILURE PROTECTION

POSITIVE NORMAL OR EMERGENCY POSITIONS ONLY

investigate TRANS-O-MATIC AUTOMATIC TRANSFER SWITCHES

Trans-O-Matic's compact, failure-proof design employs two standard circuit breakers, one from the normal and one from the emergency source, either of which will supply the load. Relay-actuated motor operates circuit breakers for positive mechanical transfer with continuous service in normal or emergency position. Available in capacities to 600 volts, 800 amps, interrupting capacities to 50,000 amps RMS. Prompt delivery in most sizes.

OPTIONAL FEATURES

Adjustable time delay on restoration to 20 minutes • Engine starting contact • Test pushbutton • Pilot lights for switch position • Special enclosures

LAKE SHORE Electric CORPORATION
BEDFORD, OHIO

(*Continued from page 46A*)

New Products

Thin-Wall Coil Forms. A line thin-wall coil forms of Du Pont Mylar has been developed by Precision Paper Tube Company as a solution to insulating problems where space is at a premium. Wall thicknesses of from 0.002 inch to 0.010 inch can be supplied. The Mylar tubes are highly resistant to moisture, solvents, and chemicals and have higher dielectric strength than coil forms fabricated from other flexible insulating materials. For full information, contact Precision Paper Tube Co., Dept. EGN, 2035 W. Charleston St., Chicago 44, Ill.

Recording Film. A heat-sensitive film for graphic recording instruments features easy duplication, projection, or optical evaluation. The clear, 100-gage polyester film base is an ideal carrier for this use because of its transparency, extreme stability, and resistance to tear. Heated or pressure loaded styli render the coating transparent. The coated film may be printed with a grid using a high solvent ink which also changes the coating from an opaque white to transparent. The film is extremely thin which permits a long chart to be rolled within a small diameter. For further information contact Technical Paper Company, Inc., 2430 Linden Ave., E., Linden, N. J.

Three Converters. Three new d-c to a-c converters have been announced by Carter Motor Company, 2705A W. George St., Chicago, Ill. The refrigerator-appliance automatic marine converter runs house freezers, refrigerators, tools, and appliances from d-c or battery power. It weighs 65 pounds and its output is 750 watts. The d-c to a-c geneverters are small, light weight, and low cost in the genemotor frame. They are for control circuits and industrial applications not requiring a larger converter. The *Mark II* super converters are of improved design for longer life and better performance. They supersede previous Carter standard super converters incorporating all previously optional long life features.

Frequency Analyzer. The *TP-625* frequency analyzer determines the frequency and amplitude of the individual components of a complex wave within the frequency range of 2 to 25,000 cycles. When equipped with its auxiliary equipment, the *TP-629* control panel and the *TP-628* servo drive, the *TP-625* frequency analyzer will automatically track to a frequency established by the speed of the equipment under analysis. Odd, even, or fractional ratios can be established by the control panel. The auxiliary equipment requires only one external signal, a function of the fundamental frequency of the equipment being analyzed. For further information contact Technical Products Company, Instrument Division, 6670 Lexington Ave., Los Angeles 38, Calif.

(*Continued on page 60A*)

The development and production of the finest quality solderless terminals for your electrical circuitry requirements is AMP's primary objective. We also constantly search for allied products and application techniques that will speed, simplify, and obsolete present time-consuming sub-assembly operations. *AMP-SPIRAP* and its application technique stems from such constant searching activity.

AMP-SPIRAP is a unique, spirally-cut plastic wrapping that . . .

- eliminates tedious cable lacing, insulation damage, and pulling of wires through spaghetti tubing
- is quickly applied to wire bundles of any size up to 3½ inches diameter
- permits individual wires to be entered or led out at any point
- is quickly unwound to allow wires to be added, removed, or relocated—thereby eliminating the necessity for cutting into the cable bundle after assembly
- holds wires together tightly, but permits flexibility for forming cable
- provides mechanical protection over entire length of cable

When required for your maintenance and repair needs, *AMP-SPIRAP* is available in the U.S.A. through American Pamcor Inc.

api
AMERICAN PAMCOR INC.

Additional information about *AMP-SPIRAP* and its application versatility is available on request. *SEND FOR YOUR FREE SAMPLE TODAY.*

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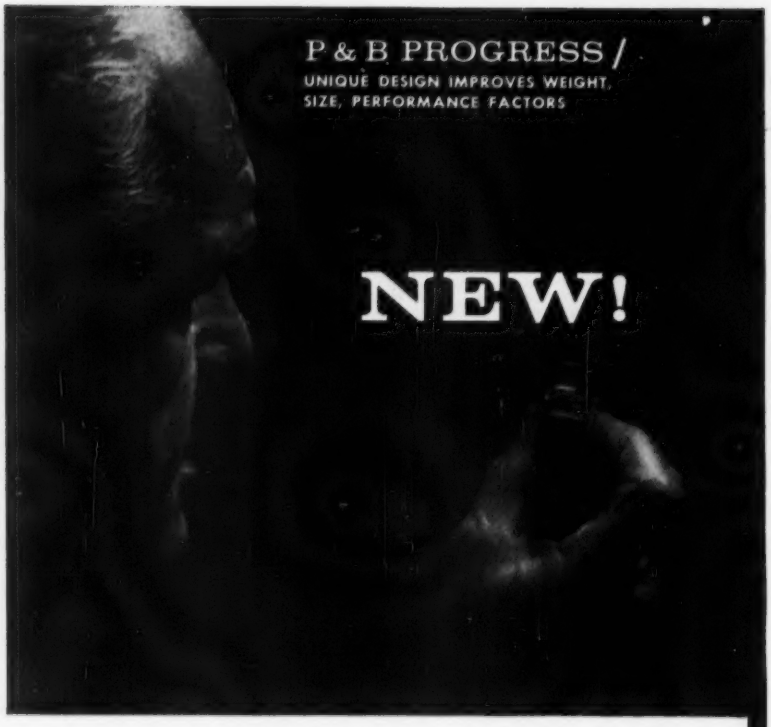
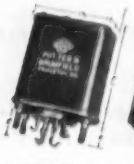


MINIATURE TELEPHONE TYPE RELAY HAS SUPERIOR SHOCK/VIBRATION RESISTANCE

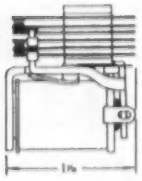
Unusual for a telephone type relay, the MG Series has excellent stability under high shock and vibration conditions. Tests show this miniature, light weight (only 1.2 oz., open) relay withstands vibration of 10g 55 to 500 cycles per second and will operate under shock to 30g according to Mil-R-5757C.

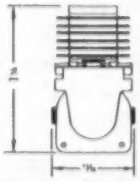
The superior performance of the MG is due in part to its unique single stack construction and to an exclusive hinge design which provides zero heel gap.

Open, dust covered or hermetically sealed, the MG is available with contact arrangements up to 4 Form C (4PDT). It is rated for ambient temperatures of −55°C to +85°C. A high-temperature version with a range of −65°C to +125°C will soon be available. Write or wire today for complete specifications and delivery information.


HERMETICALLY SEALED

POLYSTYRENE DUST COVER





MG RELAY

TERMINALS:
Open Relay: Pierced Solder Lugs.
Contacts: Two #18 AWG wires. Coil: Two #20 AWG wires.
Hermetically Sealed:
Miniature plug-in header with 7, 9 or 14 pins. Multiple Solder header with hook and terminals for three #20 AWG wires.
Polystyrene Dust Cover: Micro Ribbon plug-in type.
Mating receptacle: Amphenol #57-20140 or similar.
INSULATION RESISTANCE: 100 megohms min.
VIBRATION: .065" excursion 10-55 cps. 10g 55-550 cps. upon request.
SHOCK: 30g according to Mil-R-5757C upon request.
TEMPERATURE RANGE: −55°C to +85°C.
WEIGHT: 1.2 ozs. (open) 2.0 ozs. (sealed).
PULL-IN SPEED: Approximately 15 ms at nominal voltage.
DROP-OUT SPEED: Approximately 10 ms at nominal voltage.
CONTACTS: 3/32 silver.
CONTACT ARRANGEMENT: 4 pole, double throw (4 Form C).
COIL POWER: 3 watts max. DC @ 25°C. Continuous duty.

P&B Representatives in Canada: Aeromotive Engineering Products, Montreal
A.T.R. Armstrong, Ltd., Toronto • Charles L. Thompson, Ltd., North Vancouver

Potter & Brumfield, inc.

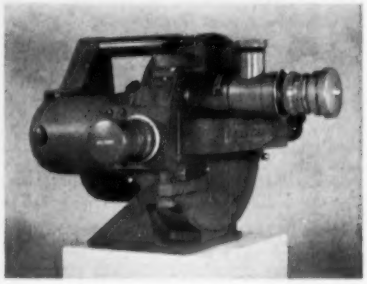
PRINCETON, INDIANA

SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

(Continued from page 58A)

New Products

High Speed Cameras, Analysis Projector. A FASTAX high speed motion-picture and oscillographic camera, a 16-mm motion picture analysis projector, and an improved FASTAIR motion picture missile camera have been announced by Wollensak Optical Company, Avenue D & Hudson, Rochester, N. Y. The FASTAX-WF-17 high speed motion picture and oscillographic camera was designed to record both mechanical and electrical data on the same film. It is particularly useful where studies of short duration are required. The 16-mm motion analysis projector was developed for the study and



analysis of subjects filmed by high speed motion picture cameras. Films can be projected without flicker as slowly as 2 frames per second. In addition, normal speed of 16 frames per second, frame-by-frame or still picture projection may be shown. The improved FASTAIR high-speed missile camera in addition to its rugged construction capable of withstanding extremely high "G" loads, severe vibration, impact and shock, will accept 50-foot and 100-foot daylight loading magazines and incorporates the revolving prism principle. This feature eliminates one of the photographer's major problems in location photography.

Tape Reader. Combining the advantages of both tape and card readers, the new Tape-ard Reader manufactured by California Technical Industries, 1434 Old County Rd., Belmont, Calif., features the unique ability to read 10 transverse rows of 8 holes each in a perforated tape simultaneously. Providing the convenience in handling data in a fixed sequence afforded by tape, the unit can supply 80 bits of information for each event without the use of memory circuits required by single-line readers. Applications with these requisites include the programming of automatic production and test equipment. With its ability to read a complete field of data, the unusual device presents simplifications and new techniques for manufacturers of business machines, computers, and similar equipment where tape or card programming and data storage are used. For further information contact the manufacturer.

(Continued on page 67A)

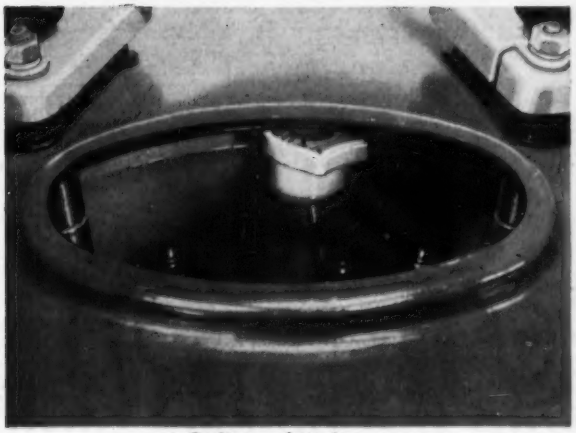
To Serve Better—Electrically

Quick, Sure Inspections

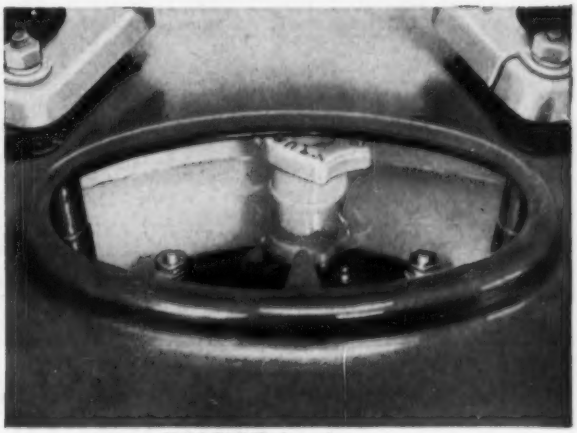
IN THE YARD

ON THE POLE

MADE EASY WITH EXCLUSIVE KUHLMAN Clearvue INTERIORS



Ordinary Interior



CLEARVUE Interior

You can simplify and speed accurate transformer inspection—in the yard or on the pole—with the exclusive **KUHLMAN CLEARVUE** Interiors.

The value of **CLEARVUE** interiors is dramatically illustrated in the photographs above. Ordinary interiors are difficult to work in, even under good light conditions. With the gleaming **KUHLMAN CLEARVUE** interiors, even the immersed transformer components are sharply visible. This clear view insures correct, fast changes of taps or leads in either bright sunlight or flashlight.

Introduced less than a year ago, **KUHLMAN CLEARVUE** transformers are being specified by increasing numbers of progressive utility operators. They realize that time can be saved and inspections improved when **KUHLMAN CLEARVUE** transformers are used. Make the **CLEARVUE** comparison yourself . . . or let your **KUHLMAN** representative demonstrate the improvement that it makes. And, when you're buying, remember that **ONLY KUHLMAN** distribution transformers have the proven **CLEARVUE** interiors.

KUHLMAN

HOUSEPOWER HELPS YOU LIVE BETTER ELECTRICALLY

LIVE BETTER ELECTRICALLY

BAY CITY, MICHIGAN • CRYSTAL SPRINGS, MISSISSIPPI • SALINAS, CALIFORNIA

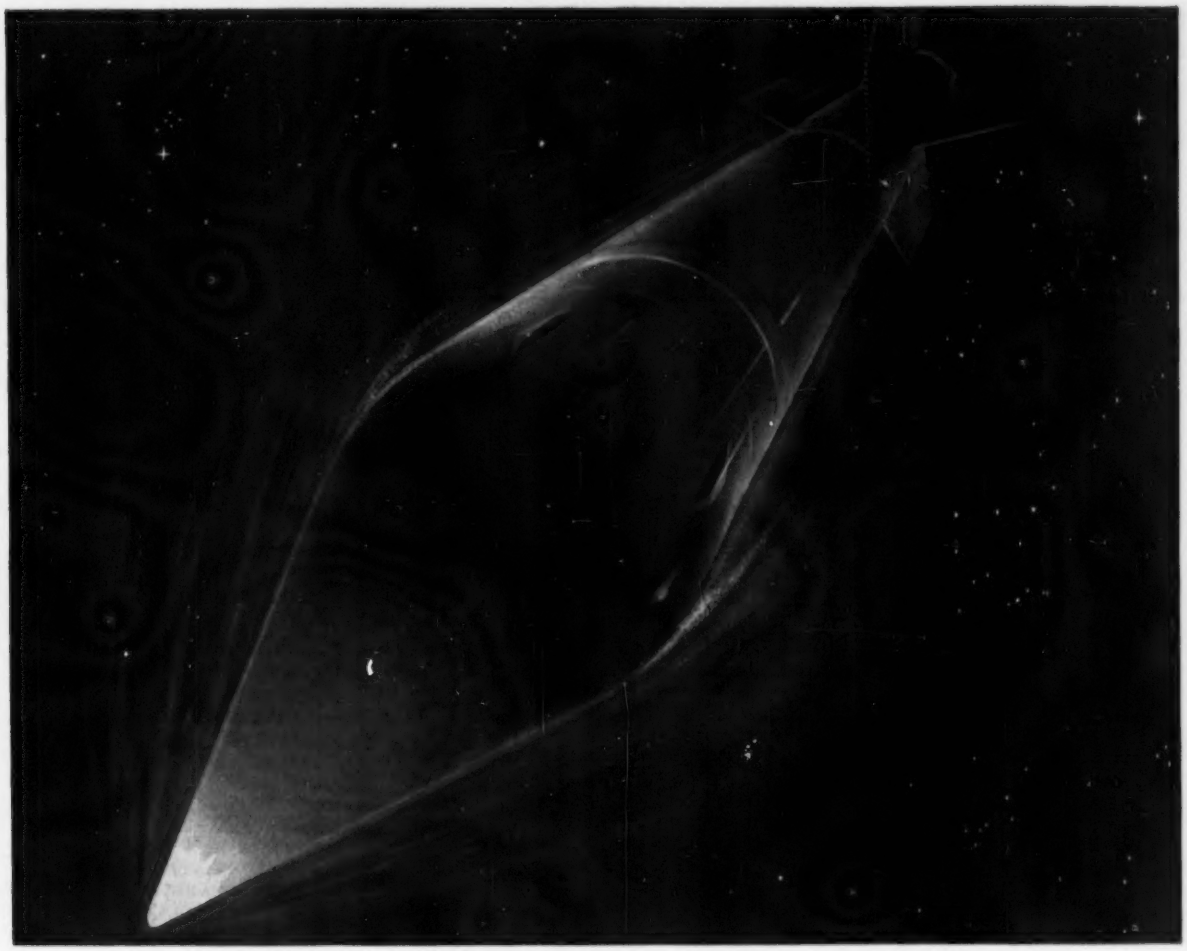
The motor with the built-in hush ...Westinghouse Life-Line A

Tests prove the Life-Line® "A" motor is the quietest available for air-conditioning applications and other places where motors must be quiet. Studies in soundproof laboratories prove the operating sound level of these Life-Line "A" motors is lower than any other standard motor.

Precision manufactured parts, dynamically balanced, assure dependable service. Possible vibration is minimized by rugged mounting of this smooth-running Westinghouse motor. Pre-lubrication coupled with Life-Line "A" fortified insulation and close-tolerance machining offers the nearest thing to a maintenance-free motor available.

For further information on the Life-Line "A" motor, call your Westinghouse sales engineer or write Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21996

YOU CAN BE SURE...IF IT'S Westinghouse



Sustained operating temperatures up to 400° F, as in guided missiles, are death to inferior electrical insulations and laminates. CDF glass-base laminates of Teflon*—the only laminates of their kind approved by the military—can take this punishment steadily.

LATEST HIGH-HEAT INSULATION SYSTEMS NEED CDF GLASS-BASE LAMINATES AND TAPES

Widest available range offers Teflon, epoxy, silicone, mica products for dimensional stability under continuous heat

As components and equipment grow smaller, and heat becomes more difficult to dissipate, CDF high-heat electrical insulations become increasingly important to electronic design. For nowhere else can such a wide range of quality insulations be found under one roof as at CDF.

FOR HIGH-HEAT PRINTED CIRCUITRY, CDF glass-base metal-clad laminates of Teflon* and epoxy exhibit best dimensional stability and current-carrying capacity. Constant operating temperatures of 300°F — soldering temperatures to 500°F — are readily met by these specialized CDF Dilecto® laminates.

HIGH-HEAT FLEXIBLE INSULATIONS. CDF offers a wide choice of insulating tapes made of Teflon, silicone varnish, silicone rubber, and Micabond®, with glass-cloth support. CDF tapes may be used either by hand wrapping or on automatic winding machines. Unsupported Teflon in colors available to meet MIL-STD 104.

TEFLON SPAGHETTI TUBING AND OTHER SPECIALTIES. Part of CDF's vast fabrication facilities is devoted to the production of custom parts from Teflon — spaghetti tubing, rods, sheets, and machined parts to rigid specifications.

NEW — *cementable* Teflon, bondable to itself and to other materials with commercial adhesives.

SEE SWEET'S Product Design File, Electronics Buyers' Guide, and other directories for the name and phone number of your CDF sales engineer. Then send your print or your problem, and we'll return specific technical data and test samples.

*trademark of DuPont tetrafluoroethylene resin

CDF **CONTINENTAL-DIAMOND FIBRE**

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ENGINEERING MEMO FROM KAISER K/W

6.1

[ANOTHER KW PRODUCT DEVELOPMENT]

AAAC*...ALL-ALUMINUM ALLOY CONDUCTOR

BY

NEIL BARR
Chief Engineer—Electrical Conductor Division

H. S. SPAULDING
Assistant Chief—Corporation Metallurgical Dept.

ANDREW L. KOLB
Manager Electrical Product Development Department

E. W. GREENFIELD
Head, Electrical Engineering Department, Division of Metallurgical Research

The lower cost and availability of E.C. aluminum and ACSR and their excellent performance record have resulted in their increased use as transmission, distribution (primaries and secondaries) and service drop conductors. In lines being constructed today either all-aluminum or ACSR is probably used in 95% of transmission, 50% of distribution and 60% of service drops.

In transmission lines the cost of high strength structures, with associated insulators and accessories, usually necessitates the use of high strength conductor when economics are considered. ACSR has for many years satisfactorily filled this need. Transmission lines have relatively few taps or other connections and their importance justifies the use of the best available accessories such as compression splices and dead-ends. Since transmission line rights-of-way are usually cleared of all obstructions, they are seldom bothered by falling trees or sleet-loaded tree limbs. Conductor repairs are not often required.

Distribution lines with their many taps and connections of all kinds present a different problem. It is not always possible to trim trees, so sleet storms and high winds usually result in considerable conductor damage due to swinging or falling branches. With the many taps and more frequent conductor repairs, the steel-cored ACSR does present some problems, especially when it is desirable or necessary to do live line repair work. Due to new building projects and added load, it is frequently necessary to revise or rebuild distribution circuits.

In some instances E.C. aluminum conductors can be used in distribution circuits, but in the smaller sizes, usually in the heavy loading district, additional strength is frequently required. To date, this strength requirement has been fulfilled by using ACSR with the associated problems of splicing, dead-ending and repairs.

Conditions outlined above pointed to the need for a satisfactory high-strength aluminum conductor that would enable users to take advantage of the cost differential between aluminum and copper. We believe a high-strength high-conductivity aluminum-magnesium-silicon alloy conductor such as we have developed over the past years meets these requirements. Some of its advantages are listed below:

1. Increased strength over E.C. aluminum
2. One-piece splice develops full strength
3. Simple to dead-end
4. Emergency splices can be made with automatic type units
5. Lighter in weight than ACSR
6. One metal, which alleviates galvanic corrosion possible with ACSR in some highly corrosive atmospheres
7. Desirable electrical characteristics—especially a-c/d-c resistance ratio, which is about 1.00, the same as for copper or its equivalent E.C. aluminum as compared with about 1.25 for some of the larger sizes of ACSR made of one layer of aluminum over a single solid steel core wire.

Since ACSR satisfies strength requirements with a practical size, an alloy which has a strength and conductivity equal to these composite properties of ACSR will also be satisfactory. The examples in Table I show what these properties of the alloy should be.

Therefore, with the strength of the aluminum strands as 25,000 PSI, and that of the steel (at 1% extension) as 170,000 PSI, the average tensile strength of the conductor is 45,700 PSI.

The initials AAAC are not a trade-mark of Kaiser Aluminum, but are regarded as a grade designation for All Aluminum Alloy Conductor (developed by Kaiser Aluminum). The initials are intended to be used freely throughout the industry in designating such products, as is the case with grade designation ACSR, Aluminum Conductor, Steel Reinforced. While testing continues, AAAC will be available in limited quantities through Kaiser Aluminum sales offices and distributors; redraw rod will later be available to other fabricators of electrical conductor.

FOR EQUAL CONDUCTIVITY

ACSR	ALLOY
Area = 6 Al + 1 steel	Area = 7 Al
Conductivity_{av} = 6 Al (61%) + 1 steel (0%)	$\text{Desired Conductivity}_{av}$ = 52.3%
= 6/7 × 61% = 52.3%	Conductivity = 7/7 (52.3%)

FOR EQUAL STRENGTH

ACSR	ALLOY
Strength = 6 Al (25,000) + 1 steel (170,000) = (320,000 PSI)	Desired average strength = 45,700 PSI
av PSI/strand = 320,000 / 7 = 45,700	

TABLE I

Hence, from high-strength high-conductivity alloy with electrical conductivity of 52.3% and tensile strength of 46,000 PSI, a conductor can be designed that will be no larger in diameter than ACSR, which will have the same d-c resistance and strength as ACSR. It offers these advantages:

(1) Not difficult to splice—since only one splicing unit is necessary, which is standard practice with all aluminum or copper conductor.

(2) Not difficult to dead-end—since no separate clevis is necessary for the core and aluminum strands. The alloy conductor is stiffer than E.C. aluminum, but there is no extra stiff core wire to cause "basketing" when the conductor is bent to form around an insulated clevis or similar dead-end device.

(3) Quickly repaired—if a company is satisfied with past records of automatic splices or dead-ends on copper or aluminum, the alloy may be repaired in the same manner. Automatic dead-ends for ACSR require that both the steel and aluminum be separately gripped. This rules out the advantage of making electrical taps on the non-tension leg at dead-ends. With alloy conductor there is no need of separately gripping the aluminum and core wire.

(4) More favorable weight—since by equal volume steel is three times as heavy as aluminum and the core wire will now be alloy instead of steel. The alloy conductor will only weigh about 80% as much as the equivalent ACSR. (Consider the weight of 6 aluminum strands + 3 equivalent aluminum strands in the steel core wire replaced by 6 aluminum + 1 additional aluminum strand in the core. The total weight then is 7/9 that of ACSR, or approximately 80%.)

(5) Mono-metallic conductor—rather than two metals as in ACSR. The oxides of most aluminum alloys make the alloys self-protecting. Such is the case of the alloy considered here. In most areas where there is a corrosive atmosphere some method of core protection for ACSR can be used to protect the conductor—such as heavier galvanizing on the core wire or protection with petroleum compounds, but the fact still remains that steel and aluminum are far enough separated in the galvanic series that if the protective medium or the zinc separator is damaged, galvanic corrosion can occur and aluminum is the sacrificial metal.

This conductor has been named AAAC (all aluminum alloy conductor). It has a conductivity of 52 to 53% IACS and a tensile strength of 48,000 to 50,000 PSI depending upon the size of the wires used to fabricate the stranded conductor. This is a heat-treatable alloy drawn to desired size and heat treated to develop its electrical and physical properties.

Laboratory experimentation has advanced to the point where it becomes necessary to have field evaluation. It is a well known fact that laboratory aging and evaluation tests are good to a limited extent but cannot in all cases be correlated to field results. Such factors as corrosion, fatigue endurance limits, and notch sensitivity can be evaluated only by field service. The above factors are not primarily important in triplex service drops, for example, since there is little danger of the conductor being nicked or subjected to severe stress. The same is also true of weatherproof conductor. The tensions will be relatively low and the conductor will be protected from contaminants by a weatherproof covering. Field evaluation has begun on the alloy used as WP conductor or triplex neutral. Use of bare conductor is at present on an experimental basis only.

One example of field evaluation of interest, but which from laboratory examination could only be surmised, was noted during a recent installation in the East of bare 1/0 equivalent AAAC. Two of the three phase wires were pulled in over the cross arms using rollers and the conductor was kept off the ground by proper blocking over rocks, shrubs and tree stumps. The third phase was pulled in by dragging it over the cross arms and through brush and rocks. This third phase was examined and it was noted that there were few scratch or score marks such as are ordinarily found on E.C. when it is subjected to this mistreatment. It is noted that the Brinell hardness of the material is about 85. An average value for E.C. aluminum is about 45 and that of hard drawn copper about 95. This indicates that one of the common complaints about E.C., namely, the ease with which the conductor is scratched, will be minimized by the use of alloy conductor.

Another interesting fact is that this is a heat-treatable alloy. As such, when subjected to a current overload resulting in a high conductor temperature, the alloy will not suffer loss in strength to the same degree as does E.C. Strain hardened E.C. metal, once heated to a high temperature, suffers a loss of strength. This is cumulative. Each time the conductor is overheated it suffers an additional loss of strength. The heat treating temperature of this alloy is much higher than ordinarily encountered in service, and as a result, it suffers slight reduction in strength until the heat treating temperature is exceeded.

Notch sensitivity is a term that is ordinarily used to express the relation between stress concentration at a nick in the wire and the resulting wire failure. Since the material is harder, it is more resistant to notching. The factor of stress concentration, once a wire is notched, is not affected by the hardness of the alloy.

Another important property of an alloy is its endurance limit. It is a well known fact that endurance limit is dependent upon the maximum tension to which the conductor is subjected in repetitive cycles. The accepted limit for E.C. Conductor is 7000 to 8000 PSI for 500 million cycles. For this alloy, the endurance limit determined in the same way is 12,000 to 13,000 PSI.

Current Carrying Capacity

One useful formula for current carrying capacity is:

$$I = \sqrt{\frac{3.77 \times 10^4 (W_R + W_C) D}{R_{AC}}}$$

The terms W_R and W_C are respectively heat loss quantities due to radition and convection. They depend on pressure and temperature, but not on the basic metal involved. W_R also includes an emissivity factor which is more dependent on the surface condition of the conductor than the type of conductor metal.

Design of the alloy conductor is based on the d-c resistance of E.C. aluminum at 20°C. This is the same basis as used for ACSR conductor. On this basis, since the alloy has been shown to have the same composite conductivity of ACSR (approximately 52.3%), the diameters are, for all practical considerations, the same. For example, see Table II.

Since the diameter of ACSR and its equivalent AAAC are the same, the only factor which can vary the current carrying capacity of the conductor is the a-c resistance at the operating temperature.

The a-c resistance of conductor is dependent upon the d-c temperature coefficient of resistance, iron losses, and skin effect. In ACSR, all three factors are present while in AAAC the iron losses are absent. Therefore, the alloy has a lower a-c resistance than ACSR. Since current carrying capacity is in-

SIZE	STRANDING	OUTSIDE DIAM. IN.
No. 6—6/1 ACSR (TURKEY)	6/1 × 0.0661	0.198
No. 6 Equivalent Alloy (AKRON)	7 × 0.0657	0.197
No. 4/0—6/1 ACSR (PENGUIN)	6/1 × 0.1878	0.563
No. 4/0 Equivalent Alloy (ALLIANCE)	7 × 0.1884	0.565

TABLE II

Kaiser Aluminum

CONTINUED ON NEXT PAGE

versely proportional to the square root of the a-c resistance at the operating temperature, the current carrying capacity of alloy conductor is higher than that of ACSR.

* * *

During the electric industry's rapid expansion, Kaiser Aluminum has concentrated intensively on utility problems—with special emphasis on covered wire.

Today, Kaiser Aluminum is the nation's fastest growing producer of aluminum wire and cable, making available the latest helpful information on modern products and practices.

A Kaiser Aluminum representative or a KW distributor will be glad to give you immediate attention. Call your Kaiser Aluminum sales office. Kaiser Aluminum & Chemical Sales, Inc., *Executive Office*, Kaiser Bldg., Oakland 12, California; *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois.

REPRINTS OF THIS ARTICLE AVAILABLE ON REQUEST

BARE AAAC (ALL ALUMINUM ALLOY)

Code Word	E.C. Equiv. Size	AREA		STRANDING			
					Diameter, In.		
		CM	Sq. In.	No.	Strand	Conductor	Strength Lbs.
Akron	6	30,210	0.0237	7	0.0657	0.197	1068
Athens	5	38,130	0.0299	7	0.0738	0.221	1348
Alton	4	48,110	0.0378	7	0.0829	0.249	1700
Austin	3	60,670	0.0477	7	0.0931	0.279	2144
Ames	2	76,440	0.0600	7	0.1045	0.314	2700
Astoria	1	96,480	0.0758	7	0.1174	0.352	3410
Azusa	1/0	121,400	0.0953	7	0.1317	0.395	4290
Anaheim	2/0	156,200	0.1227	7	0.1494	0.448	5301
Amherst	3/0	197,100	0.1548	7	0.1678	0.503	6687
Alliance	4/0	248,500	0.1952	7	0.1884	0.565	8430
COMPARATIVE DATA ON ACSR FOR EASY REFERENCE							
	Size	Aluminum Area					
Turkey	6	26,240	0.0206	6/1	0.1661	0.198	1170
Thrush	5	33,090	0.0260	6/1	0.0743	0.223	1460
Swan	4	41,740	0.0328	6/1	0.0834	0.250	1830
Swallow	3	52,620	0.0413	6/1	0.0937	0.281	2250
Sparrow	2	66,360	0.0521	6/1	0.1052	0.316	2790
Robin	1	83,690	0.0657	6/1	0.1182	0.355	3480
Raven	1/0	105,600	0.0829	6/1	0.1327	0.398	4280
Quail	2/0	133,100	0.1045	6/1	0.1490	0.447	5345
Pigeon	3/0	167,800	0.1318	6/1	0.1672	0.502	6675
Penguin	4/0	211,600	0.1662	6/1	0.1878	0.563	8420

BARE AAAC (ALL ALUMINUM ALLOY)

Code Word	E.C. Equiv. Size	RESISTANCE ohms/1000 ft.		Inductive Reactance ohms/1000 ft. at one foot Spacing 60 CPS	WEIGHT—Lbs.	
		R_{DC} 20°C	R_{AC} 20°C		Per 1000 Ft.	Per Mile
Akron	6	0.6580	0.6580	0.1172	28.2	148.9
Athens	5	0.5218	0.5218	0.1145	35.6	188.0
Alton	4	0.4137	0.4137	0.1124	44.9	237.1
Austin	3	0.3281	0.3281	0.1097	56.7	299.4
Ames	2	0.2602	0.2602	0.1071	71.4	377.0
Astoria	1	0.2063	0.2063	0.1044	90.1	475.7
Azusa	1/0	0.1635	0.1635	0.1017	112.4	593.5
Anaheim	2/0	0.1297	0.1298	0.0988	145.9	770.4
Amherst	3/0	0.1029	0.1030	0.0962	184.1	972.0
Alliance	4/0	0.0816	0.0817	0.0935	232.1	1225.0
COMPARATIVE DATA ON ACSR FOR EASY REFERENCE						
Turkey	6	0.6580	0.6580	0.122	36.1	191
Thrush	5	0.5218	0.5218	0.119	45.5	240
Swan	4	0.4137	0.4137	0.116	57.4	303
Swallow	3	0.3281	0.3281	0.114	72.4	383
Sparrow	2	0.2602	0.2602	0.112	91.3	482
Robin	1	0.2063	0.2063	0.110	115.2	608
Raven	1/0	0.1635	0.1635	0.108	145.2	766
Quail	2/0	0.1297	0.130	0.105	183.1	966
Pigeon	3/0	0.1029	0.103	0.102	230.8	1219
Penguin	4/0	0.0816	0.0824	0.0992	291.1	1537

Kaiser Aluminum

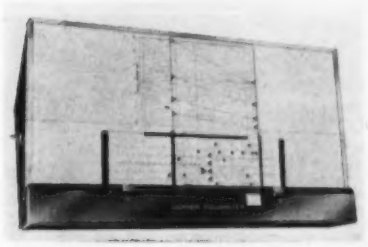
IF IT CARRIES CURRENT, KW CARRIES IT!

LIVE BETTER ELECTRICALLY

(Continued from page 60A)

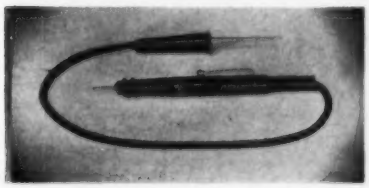
New Products

Computer. The Model *GEQ-450* equameter is a manually operated computing device which performs harmonic analyses and curve fittings on plotted or recorded curves. This instrument is capable of analyzing a curve in terms of Fourier series, power series, or orthogonal polynomials (least square fits). It will also produce the derivative or integral equations of a given curve. These equations are obtained directly from readings taken from the Equameter and recorded on specially designed data sheets. An outstanding feature of this



Equameter is that any of these equations can be obtained quickly and easily by an engineering aide with little or no mathematical background. This feature, coupled with its low cost makes it a practical instrument for many individuals and small laboratories, as well as larger installations. The Equameter is manufactured by The Gerber Scientific Instrument Company, 162 State St., Hartford 3, Conn.

Single Pole Voltage Tester. The Tip Tester tests a-c or d-c voltage from 6 to 250 volts as a single pole tester. On dc the Tip Tester indicates polarity. It clips in the pocket like a pen with no dangling wires. This German import has many uses which include location of a-c and d-c positive or



negative leads, checking outlets, switches, fuses, telephones, electric motors, and appliances. It is also used for determining leakages in high voltage conductors. The distributor of Tip Tester is Rick Inc., 2210 Hampton Rd., Erie, Pa.

Miniature Recording Potentiometer. This new recording potentiometer features 2 pens, both writing margin to margin on a single 5-inch strip chart, producing two continuous records in a smaller space than that previously required for two 3-inch recorders and with better accuracy. For further information contact Westronics, Inc., 3605 McCart St., Fort Worth, Tex.

(Continued on page 75A)

"NIX!

We've tried that contact material before!"

common error in CONTACT SELECTION

Frequently, in recommending contacts, Stackpole meets the objection: "We've tried that grade before. It's no good for our equipment!"

Experience proves that such conclusions should not be reached too quickly. Certainly they should not be based on tests of only one or two contact grades.

For instance, an electrical equipment manufacturer rejected a silver-tungsten grade (made by another contact producer) because of its high contact resistance. Because of this, he ruled silver-tungsten contacts "out" of further consideration.

After considerable persuasion, a Stackpole silver-tungsten grade was finally tested and proved eminently satisfactory. *This grade, however, contained different proportions of silver and tungsten powders. Moreover, it was processed by much different methods.*

Other instances might be cited wherein prejudices against silver-graphite, silver-copper and other so-called "standard" materials were overcome by Stackpole Custom-Tailored contact grades.

Actually, Stackpole's chief contact facility is its proved ability to adapt standard materials to specific equipment. A relatively small percentage change in the metal powders used in a mix plus Stackpole's unique processing methods may make a vital difference in contact performance.

The moral then is simply this: If use of a certain contact material grade is indicated by reasons of economy, potentially desirable characteristics, ease of assembly or whatnot, the failure of one such grade only points up the need for further custom engineering.

And such failures usually provide the clues to Stackpole contact engineers as to what changes need to be made!

Stackpole welcomes the opportunity to supply convincing proof of this to quantity contact users.

STACKPOLE CARBON CO., *St. Marys, Pa.*

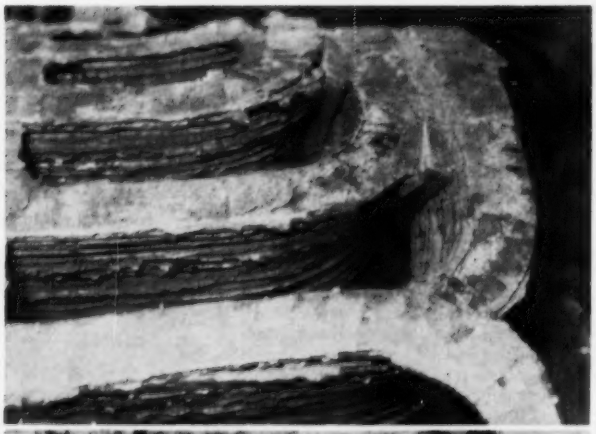
STACKPOLE

Custom-Engineered CONTACTS

Hundreds of grades in SILVER-GRAPHITE • SILVER-LEAD OXIDE • SILVER-NICKEL • SILVER-MOLYBDENUM • SILVER-TUNGSTEN • COPPER-GRAPHITE GOLD-GRAPHITE • SILVER-COPPER-GRAPHITE • SILVER-IRON OXIDE . . . and other special material combinations mixed to exacting specifications and processed from powders.

When TROUBLE Strikes

call NATIONAL



The two photos above show a typical example of copper growth which is a common cause of trouble in turbo generator rotors. Note the displacement of the top turns of the field winding. NATIONAL uses silver-bearing, surface hardened copper to minimize copper growth because it has a higher strength at elevated temperatures and resists the effect of heat cycling. The photo below shows coils being inserted in a turbo generator rotor at NATIONAL'S Columbus Plant.

for...

- fast rewinding service for minimum downtime
- high quality repairs to minimize future trouble
- redesign, where practical, to eliminate the cause of trouble

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

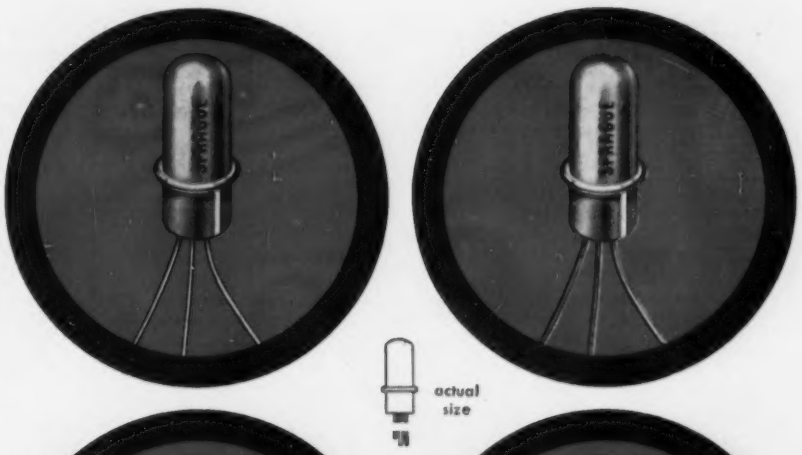
surface barrier transistors from SPRAGUE

2N344/SB101
for Medium Gain Amplifiers

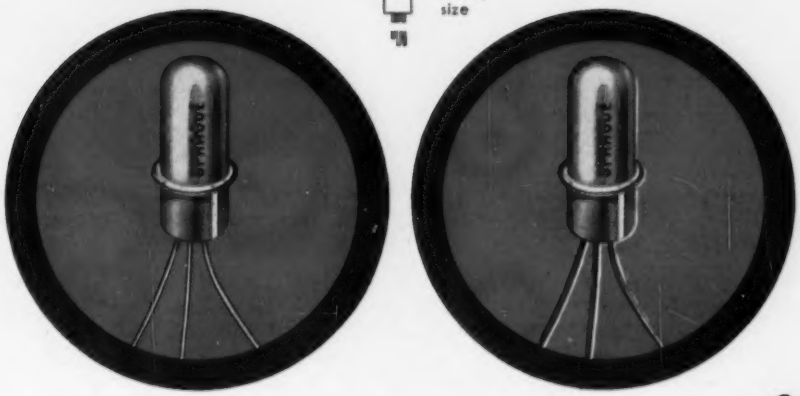
	Min.	Typ.	Max.
h_{fe}	11	23	83
f_{max}	30	45	—

2N345/SB102
for High Gain Amplifiers

	Min.	Typ.	Max.
h_{fe}	25	40	110
f_{max}	30	45	—



actual size



2N346/SB103
for High Frequency Oscillators

	Min.	Typ.	Max.
h_{fe}	10	—	—
f_{max}	60	90	—

2N240/SB5122
for Computer Switching

	Min.	Max.
h_{fe}	16	—
f_{max}	30	—
T_s	—	80

IN VOLUME PRODUCTION *Now!*

For general high frequency applications, and for high speed computer switching circuits, design around Sprague surface barrier transistors. They are available now in production quantities from a completely new, scrupulously clean plant, built from the ground up especially to make high quality semi-conductor products.

The four transistor types shown are the most popular. Orders for these units are shipped promptly. What's more, surface barrier transistors are reasonably priced. High quality and excellent electrical characteristics make them an economical solution to many difficult circuit requirements.

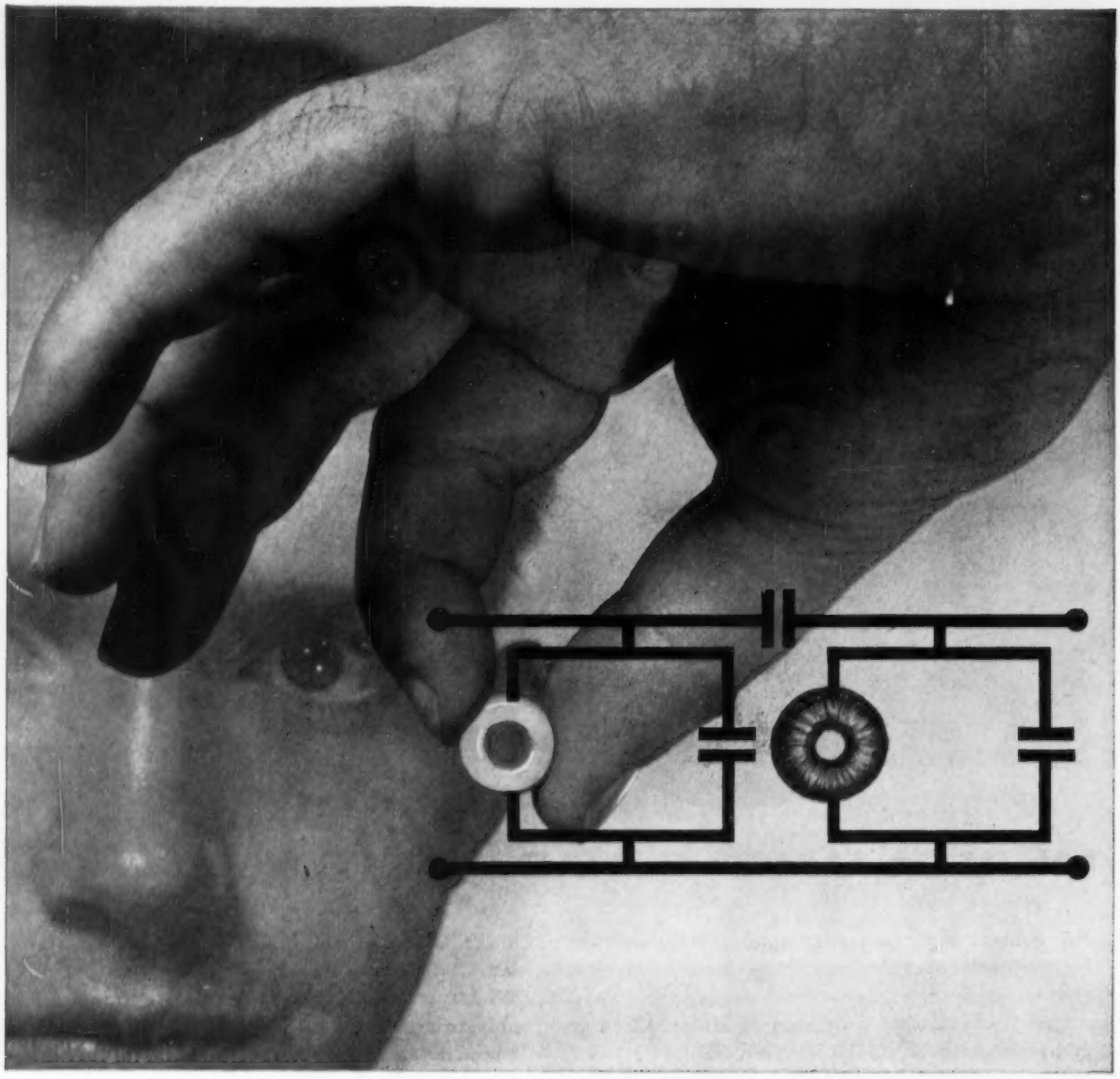
Sprague surface barrier transistors are fully licensed under Philco patents. All Sprague and Philco transistors having the same type number are manufactured to the same specifications and are fully interchangeable. You have *two* sources of supply when you use surface barrier transistors!

WRITE FOR COMPLETE ENGINEERING DATA SHEETS ON THE TYPES IN WHICH YOU ARE INTERESTED. ADDRESS REQUEST TO THE TECHNICAL LITERATURE SECTION, SPRAGUE ELECTRIC CO., 321 MARSHALL ST., NORTH ADAMS, MASS.

SPRAGUE®
the trademark of reliability

TRANSISTORS • RESISTORS • MAGNETIC COMPONENTS
CAPACITORS • INTERFERENCE FILTERS • PULSE NETWORKS
HIGH TEMPERATURE MAGNET WIRE • PRINTED CIRCUITS

KEEP-UP-TO-DATE ON MAGNETICS



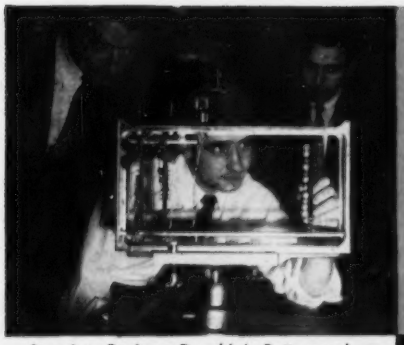
Now you can use molybdenum permalloy powder cores in miniaturized circuits

When your engineering neighbor talks about "Cheerios" these days, he's apt to be discussing a new breakfast cereal-sized molybdenum permalloy powder core which has found a happy niche as a miniaturized filter component. Guided missiles, which are filling the troposphere these days, typically use these little fellows in their amplifier circuits. Small (down to .300-in. ID), they are tough and easy to use. They also provide a markedly high degree of stability with time, temperature and magnetization.

Made by Magnetics, Inc. (Performance-Guaranteed, of course) they provide the highest permeability and lowest core losses possible in use in filter, audio and carrier frequency circuits. We provide extras, too—you may specify our very exclusive feature—color-coding. Color-coding tells your assemblers how many turns to put on your cores without the lost time and extra expense of special testing.

Want more facts? There's a brand new bulletin (PC-103A), full of important information. It's yours by writing *Magnetics, Inc., Dept. E-35, Butler, Pennsylvania.*

MAGNETICS inc.



Associate Engineer Donald A. Patterson demonstrates a problem in pluggable unit layout.

Field Engineering Instructor Joseph Rechloff explains basic display console functions at IBM, Kingston, N. Y.

Associate Engineer Robert M. Blake points out a feature of an advanced magnetic tape circuit development.

You'll find a new challenge **DEVELOPING** the world's **largest computers** at

IBM

Kingston

Staff Engineer Michael S. Zucker and associates plan electronic digital computer systems.

The design and development of SAGE (Semi-Automatic Ground Environment) computers, part of our nation's radar defense system, offer stimulating new challenges to creative engineers at IBM Kingston.

Projects currently in process include: Digital and analog systems . . . advanced circuitry . . . electronic packaging . . . communications engineering . . . simulation studies . . . air traffic control . . . automation.

If you are an electrical or mechanical engineer, a mathematician or a physicist—and want to do development work—you owe it to yourself to investigate the exciting possibilities that SAGE computers offer you at IBM Kingston.

Computer Student Stanley J. Ostrowski studies wave forms in the IBM Computer Engineering School laboratory.

FOR DETAILS,
just write, outlining background and interests, to:
Mr. R. A. Whitehorne, Dept. 309
Mgr. of Engineering Recruitment
International Business Machines Corp.
590 Madison Avenue, New York 22, N. Y.

IBM MILITARY PRODUCTS

DATA PROCESSING
ELECTRIC TYPEWRITERS
MILITARY PRODUCTS
SPECIAL ENGINEERING PRODUCTS
SUPPLIES
TIME EQUIPMENT

Plants and laboratories: Endicott, Kingston, Owego, Poughkeepsie, N. Y.; Lexington, Ky.; Rochester, Minn.; San Jose, Calif.

"We avoided costly service calls and saved our customers irritating shutdowns ..*by equipping welders we sold with Fusetron Fuses*".....

Frank Korinek, OWNER
SUN RAY ELECTRIC COMPANY
CHICAGO, ILL.

Mr. Korinek continues . . .

"About a year ago my motor rewind shop bought 62 welders for resale from a surplus dealer.

"They were 300 ampere arc welders, with the A.C. motor directly connected to a 300 ampere D.C. generator. The motor has a speed of 3500 R.P.M. and a nameplate rating of 56 amperes at 220 volts.

"The welders were equipped with 60 amp., 250 volt fuse clips. However, when we ran the welders in the shop, we found that ordinary 60 amp. fuses would blow on the starting current of the motor.

"We then tried 60 ampere Fusetron dual-element fuses. They proved to hold the starting current and to give the needed protection to the motor and generator.

"We are glad we had this experience in our own shop and installed Fusetron fuses before selling the welders. Otherwise, we would have had a flock of costly unnecessary service calls and run the risk of losing customers.

"As it happens, our customers are satisfied with the performance of the welders and we haven't had a service call or complaint about needless fuse blows."

FUSETRON dual-element FUSES do more than eliminate needless blows. They give 10 point protection not available with any other type of protective device.

AND FUSETRON FUSES REMAIN SAFE THRU THE YEARS . . .

. . . without maintenance and recalibration costs.

Once properly installed, Fusetron fuses require no costly inspection time or maintenance necessary on mechanically operated devices.

Dust, fumes, corrosion or age cannot prevent a Fusetron fuse from opening safely. There are no hinges, pivots or contacts to stick or slow down the operation of the fuse on short-circuits.

When a Fusetron fuse does open to protect, and after the fault has been corrected—the new Fusetron fuse you install has been calibrated at the factory by engineers—it is a fuse as safe and dependable as the one that blew.

DON'T RISK LOSSES! *One needless shutdown . . . one lost motor . . . one destroyed switch or panel . . . one burned out solenoid . . . may cost you far more than replacing every ordinary fuse with Fusetron dual-element fuses. Write for bulletin FIS.*

For loads above 600 amps.—Use BUSS Hi-Cap Fuses to coordinate your electrical circuits.

On 600 volts or less, BUSS Hi-Cap fuses have an interrupting capacity sufficient to handle any fault current regardless of system growth.

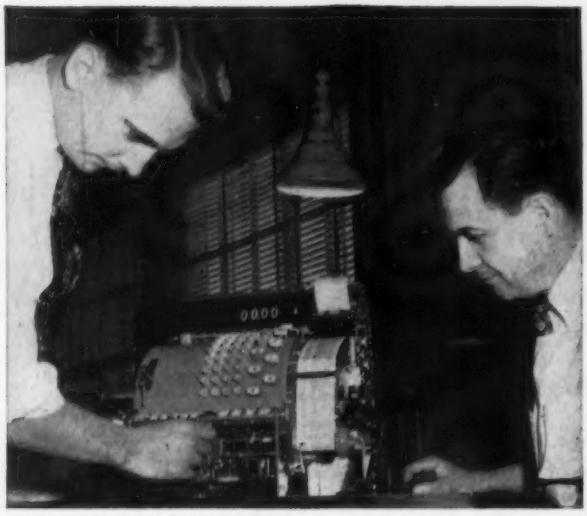
They can be coordinated with Fusetron fuses on feeder and branch circuits to limit fault outages to circuits of origin. Write for bulletin HCS.

FUSETRON
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

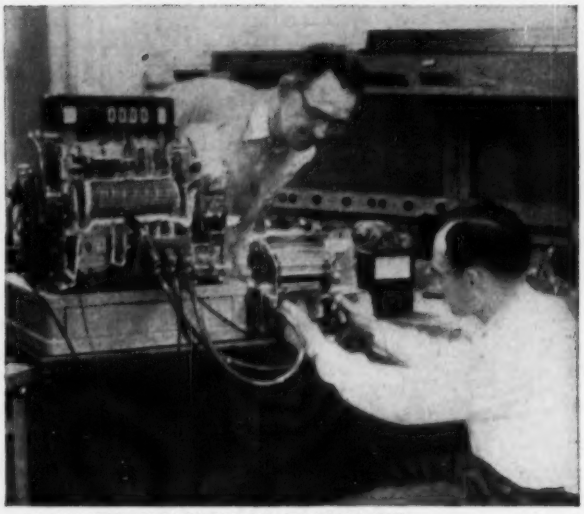
Bussmann Mfg. Division
McGraw-Edison Co.
University at Jefferson, St. Louis 7, Mo.

Play Safe! Install Fusetron dual-element fuses and BUSS Hi-Cap Fuses throughout entire Electrical System!

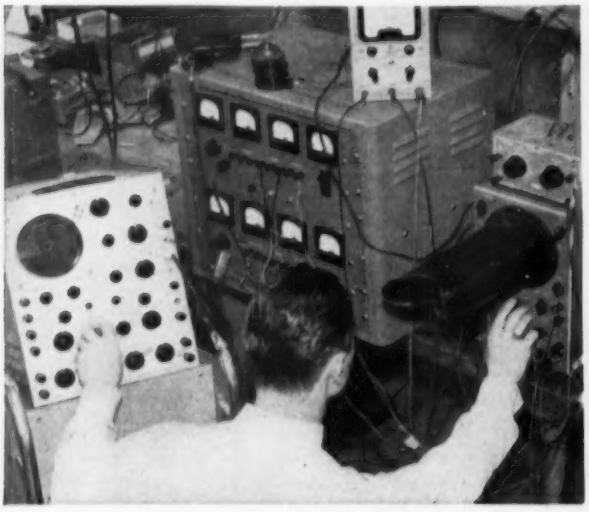
957



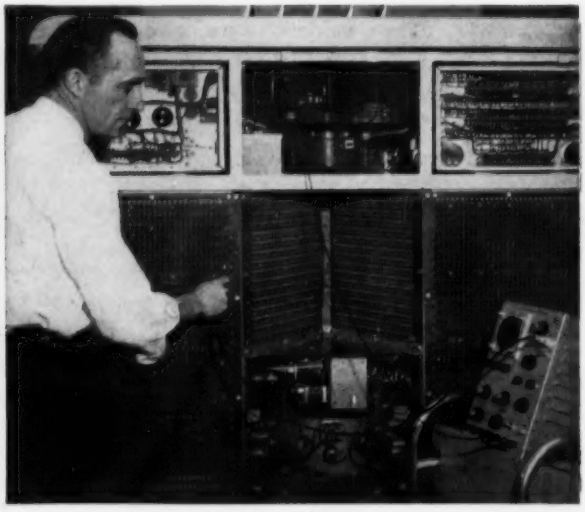
MECHANICAL ENGINEERS are using their skills in the design and development of new mechanisms required for business machines and for those mechanical products which are associated with electronic data processing equipment.



ELECTRO-MECHANICAL ENGINEERS are constantly faced with the problems of capturing information from the various input devices and converting this information into a usable form for subsequent use in data-handling equipment.



ELECTRONIC ENGINEERS enjoy an unparalleled freedom in the development of new types of circuitry and components which are necessary to maintain leadership in the competitive field of record-keeping automation.



COMPUTER ENGINEERS backed by the company's computer research since 1938 are developing an economical, flexible digital computer to meet the requirements of all record-keeping applications.

ENGINEERING UNLIMITED

AT ONE OF THE WORLD'S MOST SUCCESSFUL CORPORATIONS

If you are looking for a challenging opportunity with an established company which has tripled its sales in ten years—one that offers excellent starting salaries as well as permanent positions . . .

Act at once! Send resumé of your education and experience to Employment Department, Technical Procurement Sec. J, The National Cash Register Company, Dayton 9, Ohio.

NCR

THE NATIONAL CASH REGISTER COMPANY

(Continued from page 67A)

TRADE LITERATURE

Plastics Fabrication Booklet. L. A. Darling Company, Plastics Division, Coldwater, Michigan, fabricators of industrial plastics of all types, offers a new presentation booklet and plastics material guide. This booklet features interesting graphic examples of plastic fabrication methods with illustrations of the types of products best suited to each method. An extensive chart, showing the characteristics of tough, rigid thermoplastics is also included. Copies available on request.

Lamp Catalogue. A handy condensed catalog including contractor-dealer net prices has been issued by Steber Manufacturing Co., 2700 Roosevelt Rd., Broadview, Ill. This catalog, no. CTC-2, includes the company's complete line of sealed beam lamp components, floodlights ranging in capacity from 100 to 1,500 watts, gymnasium lighting units, high bay lighting units, service station lighting equipment, and reflectors. Available upon request to manufacturer.

Voltage Control Manual. Square D Company has published a comprehensive 12-page manual on low voltage control, the modern method of switching the lighting and appliance loads in residential, commercial, and industrial installations. The manual explains the flexibility, safety, and versatility of this economical system and points out its advantages over conventional switching systems. Write Square D Company, 6060 Rivard St., Detroit 11, Mich. for free copy.

Flow Meter Bulletin. This bulletin utilizes a novel and convenient means for aiding prospective users of Brooks Rotameter Company's flow meters in the selection of the appropriate meter for a specific application. A die-cut disc, eyeletted on the inside cover of the bulletin serves to indicate the pressure and temperature limitations of the company's rotometers as well as their flow capacity ranges. The indicated meter, in turn, is briefly described on a facing page with references to further detailed literature. The bulletin, entitled, "A Brief Guide to the Brooks Rotometer Line," is available on request. Write for Bulletin *110* to the company, Lansdale, Pa.

Bulletin on X-Ray Inspecton. A bulletin, reprint of an article from *American Aviation*, tells how United Air Lines saves thousands of dollars through use of X-ray inspection techniques, is available from the Instruments Division, Philips Electronics, Inc., 750 South Fulton Ave., Mount Vernon, N. Y. Illustrated with photographs, the bulletin discusses work with portable X-ray equipment on spar caps, stringers, rudders, fuel injection lines, door and window frames, tail structures, and fuel tanks.

(Continued on page 82A)

IMPROVE PRODUCT

REDUCE COMPONENT COST

INCREASE PROFIT

WITH ELECTRICAL GRADE LAMICOR

Class B performance at Class A cost

Lamicor, fiber glass reinforced polyester resin laminates now makes available a superior insulating material at considerable savings. Compared to all phenolic grades, LAMICOR offers the following advantages for product improvement:

Lamicor meets NEMA GPO-1 standards

300% Greater moisture resistance

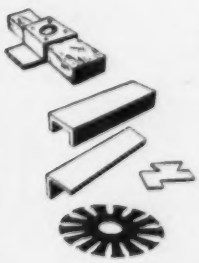
430% Greater impact strength

24% Greater flexural strength

350% Greater heat resistance

2400% Greater arc resistance

50% Cost Savings are not unusual



A complete source of supply for Lamicor sheets, channels, angles and fabricated parts.

Write today for free samples, technical information and a solution to your particular problem.

STRICK PLASTICS

PERKASIE, PENNA.

Basic Material Producers of Plastics and Laminates

Custom Vacuum Forming—Specialists on Extra Large Forms

Product Engineering and Development in Plastics and Laminates

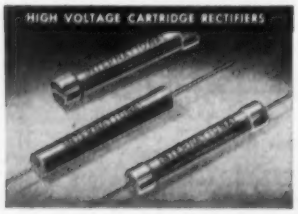
Composite Structures and Honeycomb Panels

International Rectifiers

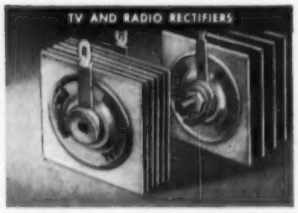
For all DC needs from microwatts to megawatts!

SELENIUM

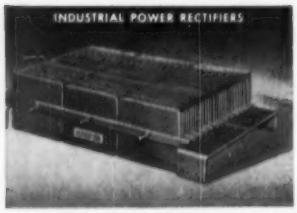
Developed for use in limited space at ambient temperatures ranging from −50°C to +100°C. Encapsulated to resist adverse environmental conditions. Output voltages from 20 to 160 volts; output currents of 100 microamperes to 11 MA. **Bulletin SD-18**



Designed for long life and reliability in Half-Wave, Voltage Doubler, Bridge, Center-Tap Circuits, and 3-Phase Circuit Types. Phenolic Cartridge and Hermetically Sealed types available. Operating temperature range: −65°C to +100°C. Specify **Bulletin H-2**

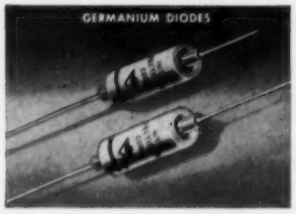


The widest range in the industry! Designed for Radio, Television, TV booster, UHF converter and experimental applications. Input ratings from 25 to 156 volts AC and up. DC output current 50 to 1,200 MA. Write for application information. **Bulletin SR-178-A**



For all DC power needs from microwatts to kilowatts. Features: long life; compact, light weight and low initial cost. Ratings: to 250 KW, 50 ma to 2,300 amperes and up. 6 volts to 30,000 volts and up. Efficiency to 87%. Power factor to 95%. **Bulletin C-349**

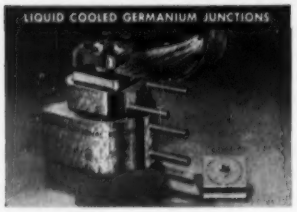
GERMANIUM



This series of general purpose, high quality point contact diodes provide excellent rectification efficiency for very high frequency applications. Special "RED DOT" series available for ambient temperatures from −55° C to +100° C. **Bulletin SR-140.**

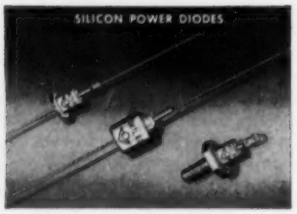
Extremely low reverse leakage values make this series ideal for magnetic amplifier applications. These units utilize 10 amp junctions—26 to 66 AC input volts rms—are available in a wide range of circuit types and DC current ratings. **Bulletin SR-149.**

Engineered for heavy power applications, these highly efficient forced air cooled units feature moisture and corrosion resistant housings. A complete series in each of 3 current ratings: 150, 330 and 500 Amperes @ 26 to 66 volts rms. Request **Bulletin GPR-2.**

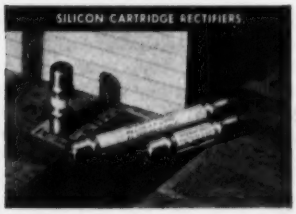


Liquid cooled for maximum power in minimum space. Junction rating: 670 amps at 26 to 66 volts rms. Housed in high-conductivity copper cast around special steel coils. Water, oil or other accepted coolants may be used. For complete data. **Bulletin GPR-2.**

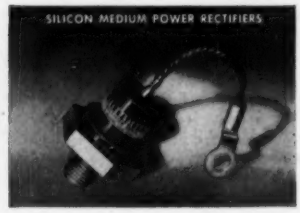
SILICON



Hundreds of types in three basic styles, for operating temperatures from −55°C to +150°C. Up to 800ma DC output current per junction over a voltage range of 50 to 1,000 PIV. Hermetically sealed. For complete information on all types. **Bulletin SR-A.**



The answer to tough miniaturization problems! Ratings for high temperature applications: from 1000 volts PIV at 100ma half-wave DC output to 16,000 volts PIV at 45ma. Hermetically sealed, metallized ceramic housing. Request **Bulletin SR-139B**



Specifically engineered for industrial applications—the most conservatively rated silicon rectifiers in the industry! Rugged all-welded construction and hermetic sealing mean greater reliability—longer life. Types available in 3 series. Request **Bulletin SR-143B.**

These units consist of hermetically sealed junction diodes mounted on copper cooling fins, stacked to include the interconnections required for specific circuits. Junction ratings: 1.25 amps. DC output; 70 to 350 AC input volts rms. Request **Bulletin SR-137A.**

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Completely Oil-Sealed!

A-B QUALITY

802TC Side Push Rod Type

802TF Rod Type

802TA Roller Lever Type

802TB Top Push Rod Type with Plastic Window

802TAO Roller Lever Type for Cavity Mounting

802TG Adjustable Roller Lever Type

SEALED HEAD KEEPS OUT OIL, COOLANT, METAL CHIPS ...your guarantee of reliable limit switch operation!

With *completely sealed* operating heads, as well as sealed switch bodies, Allen-Bradley Bulletin 802T oiltight limit switches provide maximum reliability in limit switch operation for your modern, high speed production machines. The sealed head excludes oil, dirt, and metal chips from the operating mechanism ... the spring return, momentary contact operators cannot become sluggish and stick.

The maintenance free, double break, silver alloy contacts are sealed in the oiltight body. Interchangeable operating heads are available with various push rods and levers which can be mounted in any one of four positions. Oiltight transparent plastic covers, for inspecting contacts and wiring without removing the cover, are available for most units.

Here's a line of *quality* limit switches in which each type will provide millions of trouble free operations. Have your A-B control engineer acquaint you with this latest development—another advance in limit switch design.

ALLEN-BRADLEY
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Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
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9-57-MR

NOW... ALLEN-BRADLEY PRECISION-TYPE LIMIT SWITCHES ARE ALSO OILTIGHT!

OILTIGHT HEAD — Newly designed head on push type seals out oil. Roller lever types have sealed operating shafts.

OILTIGHT BODY — Synthetic rubber gasket between housing and plate excludes oil and coolant from operating mechanism.

Allen-Bradley precision-type limit switches combine very close operating tolerances with such a sturdy construction that they can be used for any industrial application. Now this line of limit switches has been further improved by making them completely oiltight.

Especially designed for use where the motion to operate the limit switch is measured in thousandths of an inch, these Allen-Bradley limit switches can henceforth be employed in applications where oils, coolants, and dust are present.

Allen-Bradley Bulletin 802 oiltight precision limit switches have a positive snap action mechanism which prevents any possibility of a "dead center" . . . no matter how slowly the actuating force is applied. They are available in both the spring return and maintained contact construction. And all have maintenance free, double break, silver alloy contacts.

Specify these Allen-Bradley oiltight limit switches where "precision" operation is required and where dirt and oil could cause trouble.

Push rod type. Plastic cover, for inspection without removing cover, made for most units.

Roller lever type limit switch with lever on right side. Also available with lever on left side.

Roller lever precision-type limit switch with roller lever in front of the switch body.

ALSO—GENERAL PURPOSE LIMIT SWITCHES

Bulletin 801 general purpose limit switches in standard or heavy duty ratings. Maintained or momentary contacts with slow or snap action. Silver alloy contacts used throughout this line.

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A-B QUALITY

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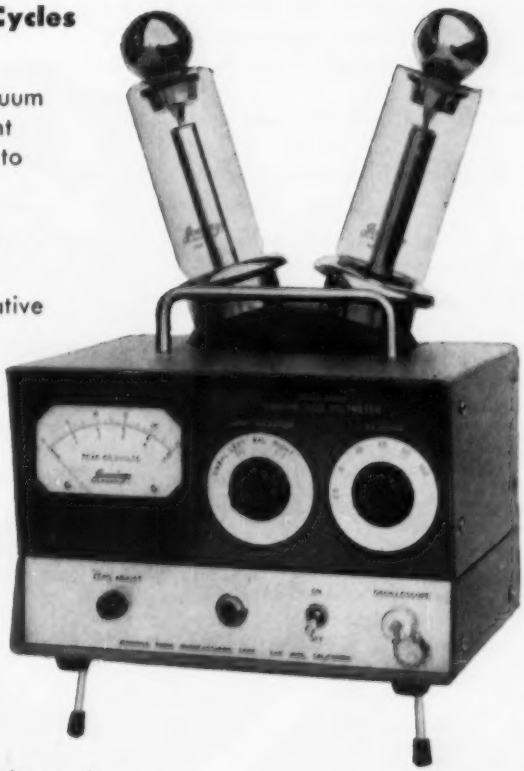
MEASURE *High* VOLTAGES

0 to 100 KV at Frequencies of 20 Cycles to 50 Megacycles



JENNINGS Model J1003 High Voltage Vacuum Tube Voltmeter is truly a versatile instrument with six direct reading linear voltage ranges to cover voltages of 0 to 100 kilovolts. It can accurately measure these voltages at frequencies from just above dc levels to 50 megacycles. There are two separate high voltage input circuits so that positive or negative peaks may either be read separately or added together vectorially.

Thus it can be used for single ended measurements of rf, audio and dc ripple voltages in radio or television transmitters, for measurements of high voltage pulses in radar and test equipment, and for measurements of magneto and ignition coil output. In these measurements one input circuit can be used to view a wave shape on an oscilloscope while the other indicates its peak value on the meter.

The instrument can also be used for the vector addition of multiphase line-to-line voltages in either balanced or unbalanced circuits, as well as for voltage readings on center-tapped transformers and push-pull tank circuits.

Jennings RADIO

Send for Catalog Literature

accessories

Type JP325 HV Probe for use with an oscilloscope where the meter indication is not required.

Type JCD5 Vacuum Capacitor to double the voltage range of the meter.

Remote Indication Kit to enable both dividers to be removed and installed close to the circuit being measured.

Panel Mounting Plates to mount the meter section on a 19" relay rack.

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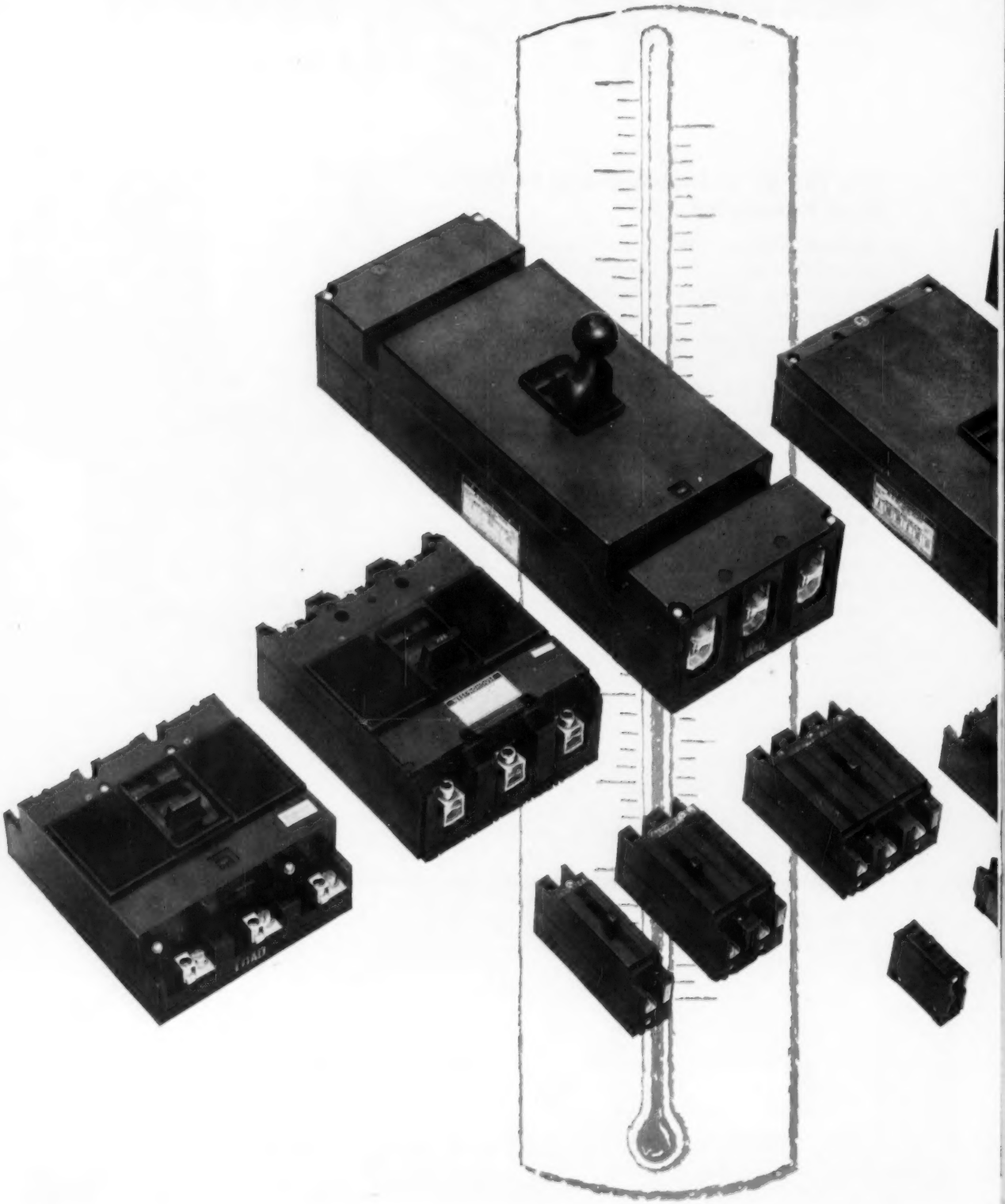
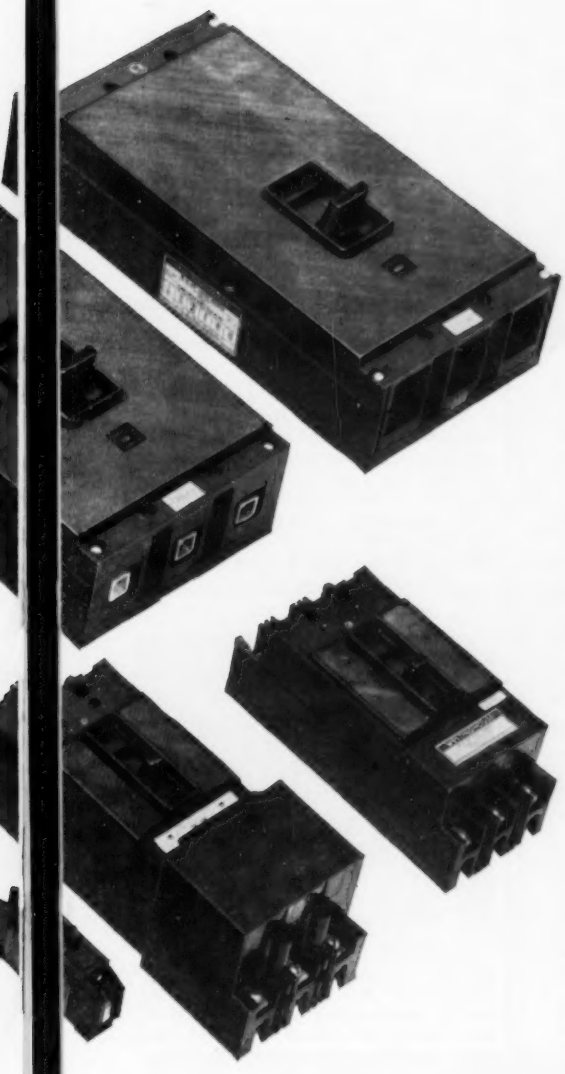
The only complete line of



ambient compensated breakers...

Westinghouse



Whenever circuit breakers are subject to wide ambient temperature variations to which associated conductors are not exposed, an ambient compensated type of breaker should be specified. This provides added insurance against current interruptions due to false high-temperature influences. The net effect is to prevent the breaker from unnecessarily derating the conductors.

Typical of the conditions under which ambient compensation may be required are . . .

In panelboards or load centers where a large number of closely grouped breakers create high temperatures.

Proximity of breaker installation to other equipment causing ambient variations to which the conductors are not exposed.

Westinghouse has the only complete line of circuit breakers to meet every requirement. (1) "Compensated for enclosure ambient," standard in Quicklag® breakers, (2) "Noncompensated for ambient re-rating," standard in Types E through M, (3) "Ambient compensated," by specification in Types E through M.

The engineering "know-how" which goes into the development of this reliable protective equipment is available to aid you in selection of the right type of breaker for your particular circuit conditions. Ask for Westinghouse Bulletin 7221 detailing technical information on the choice of circuit breakers.

J-30277

Get proper breaker protection under all ambient conditions.

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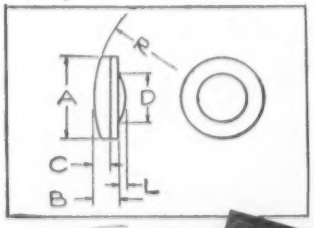
Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pennsylvania

- **HIGH CONDUCTIVITY** Gibson steelback electrical contacts are made by individually bonding each silver facing to its steel backing. When steelback is welded to support, the bond provides a highly conductive electrical and thermal path.
- **PERMANENT BOND** Excellent bond between silver and steel will not separate. No solder is in the bond. Certainty of flawless bond eliminates possibility of high-resistance joint between facing and backing.
- **NO RUSTING** Nickel plating on all surfaces of steel backing before attaching silver facing assures freedom from rust.
- **ECONOMY** Nickel or monel can be used in place of steel as backing material to prevent costly rusting if backing is damaged. For standard-size steelback quotations, submit material desired, dimensions (shown below) and ordering quantity. Special sizes also available.



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AIEE REPORTS

These publications are proposals for new standards or test codes, or revisions of present publications, which are in the formative stage. They are made available without cost, so that all interested individuals may obtain them for study and comment, thus supplying practical experience in their use before submission for adoption.

1A General Principles for Rating of Electric Apparatus for Short-Time Intermittent or Varying Duty (9-41)

52 Application Guide for Grounding of Instrument Transformer Secondary Circuits and Cases (March 1951)

56 Insulation Maintenance Guide for Large AC Rotating Machinery (May 1954)

57 Test Procedure for Evaluation of the Thermal Stability of Enamelled Wire (10-55)

58 Induction Motor Letter Symbols (January 1956)

59 Test Code for Metallic Rectifiers (March 1956)

62 Recommended Guide for Making Dielectric Measurements in the Field (11-56)

64 Guide for Maintenance of Insulating Oil (11-56)

65 Test Procedure for Thermal Evaluation of Ventilated Dry-Type Power and Distribution Transformers (11-56)

450 Guide for Specification of Electronic Voltmeters (4-55)

451 Guide for Specification of Signal Sources (April 1955)

452 Guide for Specification of Cathode-Ray Instruments (April 1955)

505 Test Code for Power Factor Testing of Power Transformers (January 1955)

506 Test Code for Power Factor Testing of Distribution Transformers (October 1955)

511 Test Procedure for Evaluation of Systems of Insulating Materials for Electric Machinery Employing Form-Wound Pre-Insulated Coils (10-56)

802 Test Code for Direct-Current Carbon-Pile Voltage Regulators for Aircraft (4-55)

954 Application Guides for: Ground-Fault Neutralizers; Grounding of Synchronous Generator Systems; and Neutral Grounding of Transmission Systems (10-54)

955 Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Clad Switch-gear (October 1955)

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street, N. Y. 18

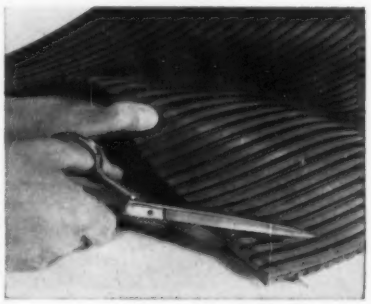
(Continued from page 75A)

Trade Literature

Pulse Calibrator Brochure. The Type *1810* pulse calibrator, an instrument designed for accurate measurement of current and voltage pulse amplitudes, pulse durations, and rise time, is now fully described in a technical brochure published recently. Free copies of this brochure are available upon request to Burroughs Corporation, Electronic Instruments Division, 1209 Vine St., Philadelphia, Pa.

Revised Socket Screws, Plugs, Pins Manual. A 32-page revision of the basic Unbrako catalog of Standard Pressed Steel Co. reviews, in detail, the complete line of standard socket screw products, pressure plugs, and dowel pins manufactured by the firm. Major product lines reviewed are heat-treated alloy-steel and stainless-steel socket-head cap and set screws. Screws range in size from the No. 0 diameter microsize set screw 1/16 inch long to the giant-size cap screw 3 inches in diameter and 12 inches long. For copies of the catalog write to A. W. Scott, Advertising Dept., Box 762, Standard Pressed Steel Co., Jenkintown, Pa.

Noise and Vibration Reduction. What looks like a simple solution to the plaguing problems of industrial din and vibration, has been announced by Vibration Mountings, Inc. (VM). According to the company its newly developed "shear-flex" mounting pads effectively reduce the noise and isolate the vibration transmitted from



all types of industrial machinery, office, and air-conditioning equipment. Shear-flex is an 18 inch square by 3/8 inch thick oil-resistant Neoprene sheet with a cross-ribbed structure that offers excellent deflection throughout the full load range of 5 to 70 pounds per square inch. The alternately raised ribs provide skid-proof surfaces. Installation is extremely simple and shear-flex can be cut to size with a scissors or knife and placed under the legs or bearing plate of equipment. There is no need for bolting or cementing. Sample swatch, vibration engineering data book, and prices are available from Vibration Mountings, Inc., 98-17 50th Ave., Corona 68, L.I., N. Y.

The Microwave Radio System *that Grows... as you Grow!*

RCA Microwave Radio Systems are designed with future needs in mind. They do not face obsolescence because of users' growth. High channel capacity permits orderly growth up to a total of 120 channels for voice, data transmission, supervisory control and other purposes.

RCA was one of the earliest pioneers in the development of microwave for commercial communications. Today, RCA Microwave Systems provide users throughout the world with many important features . . . operation in the most advantageous frequency bands, simplified installation and minimum maintenance cost.

Serving their users with dependability and precision, RCA Microwave Systems are now operated by utilities, gas and petroleum pipelines, cross country turnpikes, and government agencies.

More than a million channel miles of RCA Microwave Systems in service . . . performance proved throughout the world.

RCA Microwave specialists will be glad to answer any questions and help plan your installation. Mail coupon for further particulars.

SPECIAL NOTE TO RCA CUSTOMERS:

Ask about the RCA "Package Expansion Plan" which confirms your wise choice of RCA CW-20 or MM-26 Microwave for your communications system. A minor field modification will bring your system up to 48, 72 or even 96 channel capacity, depending on your revised requirements.

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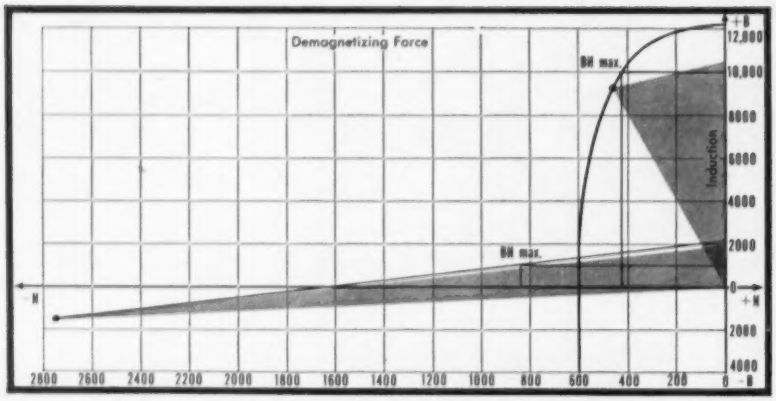


Composite of demagnetization curves showing that for Alnico V, upper, and Indox I, lower. Operation in the third quadrant is produced when a demagnetizing force, stronger than the magnet, forces flux in a direction opposite normal operation, providing negative magnetic induction. Indox magnetic flux returns to full value when this force is removed.

Why Ceramic Magnet Fields Are Now Practical for D.C. Motors

G. R. Hennig, Senior Design Engineer, The Indiana Steel Products Company, explains in this interview why Indox ceramic magnets are now practical for d.c. motors ranging from fractional to multiple horsepower.

Question: Why is the use of Alnico magnets limited to rather small motors, such as toy motors? Why are only some very special larger motors equipped with permanent magnet stators at the present time?

Answer: The price per unit of usable magnetic energy dictates the size limit. Alnico contains very expensive raw materials. For small magnets weighing a fraction of an ounce, this is not too significant. Labor cost, however, the other main factor in any calculation, is a sizeable item in small units. This is not true when larger Alnico magnets are required. With Indox the opposite is true. Its raw materials are cheaper than copper, and it appears that the larger the motor—within a certain limit—the more economically the material can be applied.

Question: How can Indox I, with only ⅕ the energy product (BH_{max}), of Alnico V, be recommended for motor usage where a high field energy is required?

Answer: Maximum energy product is a good criterion of quality for static conditions, such as in the magnet systems of moving-coil instruments or loudspeakers. In motors, generators, and many other applications where the magnet is subject to strong demagnetizing forces, maximum energy product is not an important consideration. One must consider the incremental permeability, even in the third quadrant of the hysteresis loop. The result is, that under the most extreme conditions, Indox I has a maximum usable energy of 17.4 in.-lb. per pound while Alnico V has only 13.7 in.-lb. per pound. Under conditions as found in motors, the usable energy of Indox I is about ½ instead of ⅕ of the usable energy of Alnico V.

Question: How does Indox V compare with Indox I and Alnico V, and where does this material find application?

Answer: Indox V is the strongest ceramic magnet material available today. Per unit of volume it provides more usable energy in motors than Alnico V does. Flat pieces with at least 2 sq. in. area are preferable for production. This means that Indox V is suitable for motors with about 1/25 hp and more, and not for the tiny toy motors.

Question: What are the size limitations for Indox I and Indox V motors?

Answer: Indox I is suitable for motors from the smallest possible size to about ⅛ hp. Indox V can be applied in much larger motors, possibly in the range up to 10 hp, or higher. The same applies for generators.

Question: Can any d.c. motor be converted to a permanent magnet-field motor?

Answer: Yes, most motors can be converted with very little design change. Others may require a considerable change in structure and layout of the armature.

Question: Is there a problem of meeting air gap tolerances with Indox I ring or segment stators, unless bore grinding is applied?

Answer: No. Even though there is an as-sintered tolerance of ± 1.5%, an Indox magnet may be compared with an air-core solenoid, and variations of the air gap length have little influence on the usable flux. Only the O.D. should be ground which is an inexpensive operation on centerless grinders.

Question: How will a permanent magnet motor compare with shunt or series wound motors?

Answer: In general, a permanent magnet motor will have characteristics falling between shunt and series wound motors. Although it will not duplicate the entire speed torque curve for either, it can duplicate characteristics over a specified range.

Question: What are the specific advantages of substituting permanent magnets for wound fields in motors?

Answer: The advantages are: Higher efficiency, cooler operation, less use of critical material such as copper and, possibly, simplification and cost reduction.

Question: Is there a possibility of using Indox in a.c. motors?

Answer: Yes. In addition to various synchronous timer motors, d.c. motors with Indox magnets can be used with the new, efficient power-rectifiers (silicon or others). The advantages over normal d.c. motors are higher starting torque and better speed regulation.

Question: How is the speed controlled in permanent magnet motors?

Answer: Normally, by varying the armature voltage, but also by using a magnetic shunt, by moving the armature axially out of the permanent magnet field, by rotating the brushes, or by an auxiliary field winding.

Question: Can a permanent magnet stator compete with an equal electromagnetic stator in size or total volume?

Answer: Yes, with the materials we have today it can. There is only one exception: Where wound fields are operated with high, short-time overloads.

A complete reprint of Mr. Hennig's paper, "Applying Ceramic Permanent Magnets to Motor Design" appears in the July-September *Applied Magnetics*. Write today for your copy. Dept. T-9.

THE INDIANA STEEL PRODUCTS COMPANY
VALPARAISO, INDIANA

THE WORLD'S LARGEST MANUFACTURER OF PERMANENT MAGNETS

INDIANA PERMANENT MAGNETS

In Canada . . . The Indiana Steel Products Company of Canada Limited, Kitchener, Ontario

Now--CONTROL offers you standardized saturable reactors

If you're a design engineer who would be delighted with industrial components which are sensitive and, under normal operation, last virtually forever with no maintenance or servicing, then you'll welcome CONTROL's *standard* lines of saturable reactors.

With CONTROL reactor assemblies and magnetic amplifiers, you know complete physical and operating characteristics —a copy of our Catalog R-10 awaits your request. And, delivery is fast because sub-assemblies of these units are stocked, awaiting your control-winding specifications.

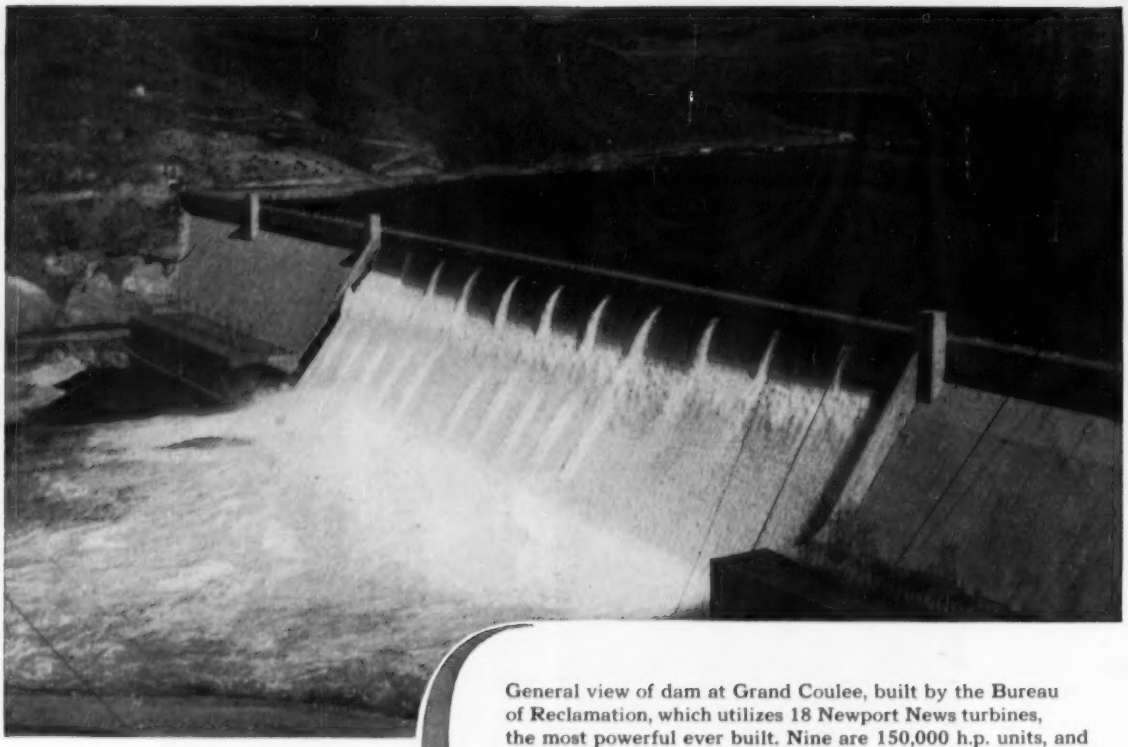
CONTROL reactors are available for both 120- and 240-volt 60-cycle operation. There are eleven standard sizes in each voltage range. They have extremely high gain. Six ampere-turns control nearly 2,000 watts in the largest size. Power outputs range from 50 to 2000 watts, with only 2 ampere-turns required for control of the smallest units.

In addition to higher gain, smaller exciting current, and fewer ampere-turn characteristics, CONTROL reactors have a 40 to 1 cut-off ratio. They are totally enclosed so that the high performance toroidal cores used are protected, and the entire assembly has the ruggedness required for long life.

CONTROL offers the same convenience of standardization in use of high permeability magnetic devices that you've enjoyed with other components. Add to this convenience ruggedness and freedom from maintenance which is unmatched, and you'll welcome CONTROL to your design picture. Write for complete details and literature today. *CONTROL, Dept.EN-37,Butler, Pennsylvania.*

Reliability begins with CONTROL

A DIVISION OF MAGNETICS, INC.



General view of dam at Grand Coulee, built by the Bureau of Reclamation, which utilizes 18 Newport News turbines, the most powerful ever built. Nine are 150,000 h.p. units, and the other nine are rated at 165,000 h.p. each.

Specialists ... in building Water Power Equipment

Typical Users of Newport News Equipment

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Folsom	California
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Hiwassee	Tennessee
Hoover	Nevada
J. H. Kerr	Virginia
Jim Woodruff	Florida
Lower Salmon	Idaho
Norris	Tennessee
Rock Creek	California
Santee-Cooper	South Carolina
C. J. Strike	Idaho
Whitney	Texas
Wilson	Alabama

Turbines designed and built for the world's largest development at Grand Coulee ... and for other hydroelectric installations in America and various parts of the world ... bespeak the skill and facilities offered by Newport News.

This trained organization has filled hydroelectric turbine contracts with an aggregate rated output of 7,000,000 horsepower.

Other equipment designed and built by Newport News includes penstocks, pressure regulators, valves, pumps, gates and rack rakes. Upon request, a copy of our illustrated booklet entitled "WATER POWER EQUIPMENT" will be sent to you.

Newport News
SHIPBUILDING AND DRY DOCK COMPANY
Newport News, Virginia

The first cost of dry-type transformers is not always the total final cost

Because *Some dry-type transformers cost more to install than others.*

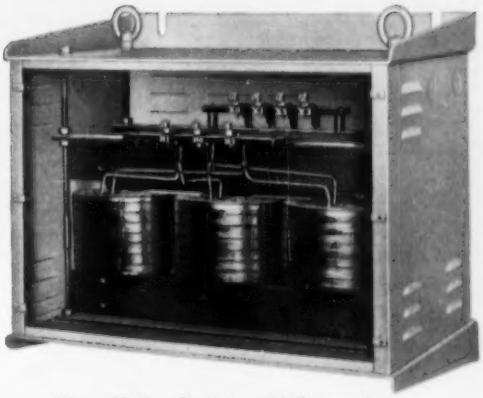
But SORGEL air-cooled dry-type transformers cost less to install because they are all self-contained in a single unit — either single phase or 3-phase — equipped with substantial wall brackets with slots for bolts, or with floor mounting base. No separate brackets to make or buy. Easily accessible, roomy connection compartment, with wide choice of knockouts. Equipped with solderless terminals and permanent connection diagram.

Because *Some must be installed in locations that require longer feeders and more expensive wiring.*

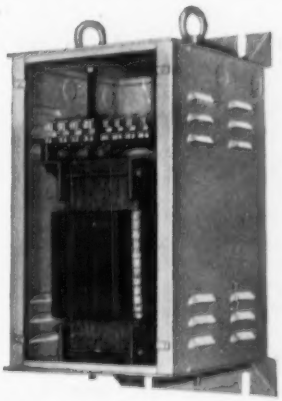
But SORGEL transformers are so quiet in operation that they can be installed in almost any convenient place inside of buildings, close to the load center. This results in shorter feeders, better voltage regulation, more efficient distribution, and lower wiring cost.

Because *Some require a larger rating for a certain load.*

But SORGEL transformers do not require a larger rating than the load, because they are guaranteed to carry their full rated load continuously at high efficiency. They are so liberally designed that they can carry an overload during an emergency at a safe operating temperature. Vacuum impregnated windings brazed to solderless terminals assure years of trouble-free service.



15 to 50 Kva 3-phase. Wall mounting.
Connection compartment panel removed.



20 to 75 Kva single phase. Wall mounting.
Connection compartment panel removed.

SORGEL TRANSFORMERS

Sales engineers in principal cities.

Consult the classified section of your telephone directory or communicate with our factory.

Stock carried by jobbers in the following cities:

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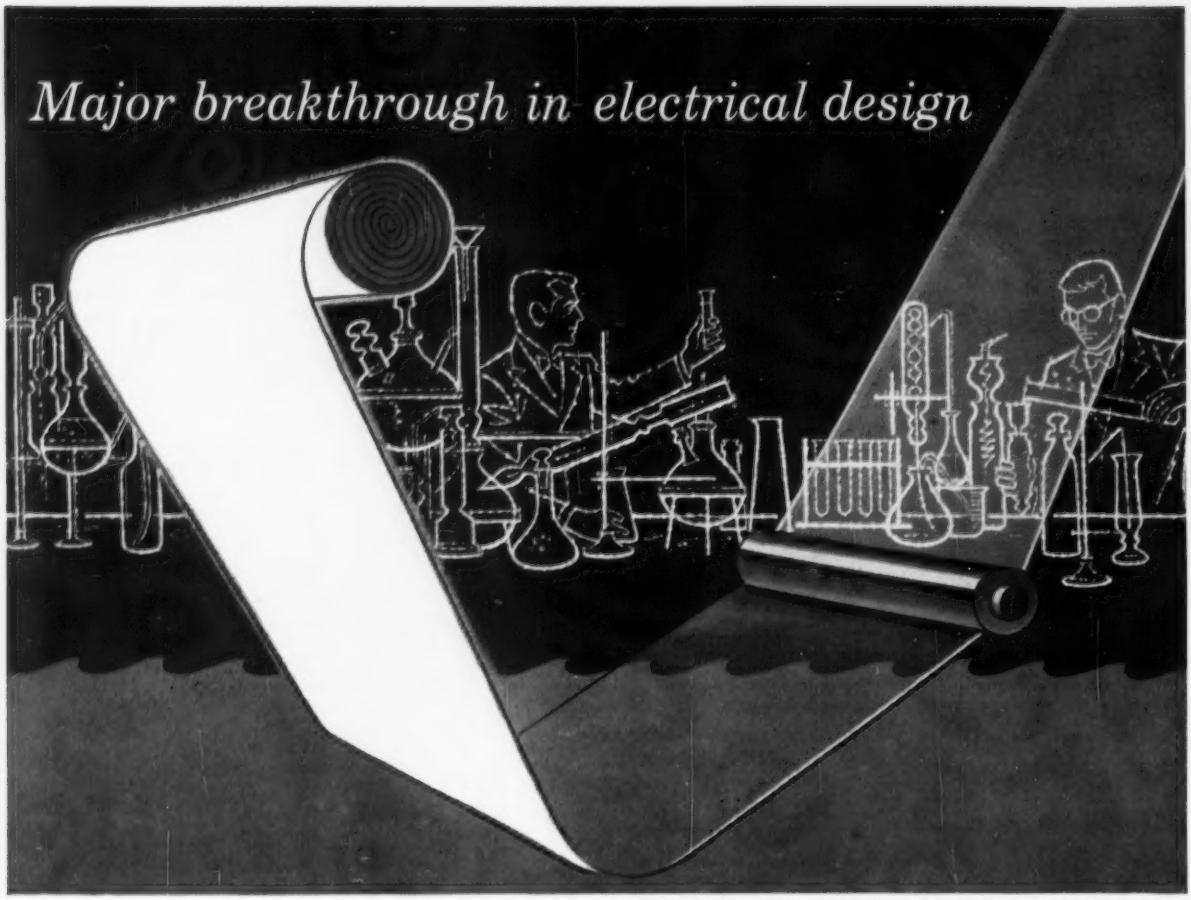
Buffalo, N. Y.	Rock Island, Ill.
Roxbury, Mass.	Rockford, Ill.
High Point, N. C.	Richmond, Ind.
Raleigh, N. C.	Cedar Rapids, Iowa
Philadelphia, Pa.	Davenport, Iowa
Cincinnati, Ohio	Omaha, Neb.
Cleveland, Ohio	Beaumont, Texas
Louisville, Ky.	Los Angeles, Calif.

Complete Line

¼ Kva to 2500 Kva single phase.
1 Kva to 3000 Kva 3-phase, 2 phase, and phase changing.
All standard voltages, such as 120, 208, 240, 480, 600, 2400, 4160, 4800, 7200, 13,200, and up to 15,000 volts, and any intermediate or special lower voltage.

SORGEL ELECTRIC CO., 846 West National Ave., Milwaukee 4, Wisconsin

40 years' experience in the development, manufacturing and application of transformers



Johns-Manville's new Type 71 Quinterra insulation combines the lasting dielectric strength of the purified asbestos base sheet and epoxy varnish.

For smaller Class B equipment . . .

New J-M Type 71 Quinterra® Epoxy-treated to double dielectric strength

Johns-Manville now opens up a new era in electrical design, with Type 71 Quinterra—the epoxy and asbestos insulation that breaks through today's limitations on ratings and size—offers untold new possibilities in compact class B equipment.

Offers 5 major improvements

1. High Epoxy Content (approx. 45% to 50%) provides the optimum electrical benefits of these high-dielectric resins and asbestos. This mechanically and electrically strong insulation combines the lasting inherent dielectric strength of the Quinterra base sheet with the excellent electrical properties of epoxy varnish.

2. Over 700 Volts/Mil is the tested and proved dielectric strength of Johns-Manville's new Type 71 Quinterra insulation. This exceptionally high characteristic offers brand-new opportunities in increased power from smaller frames—with less metal.

3. Continuous Operation to 175C with no reduction of properties brings Quinterra Type 71 well above the standard class B limit of 130C. At 175C, this new insulation exhibits a dielectric strength *well above its 700 volt per mil minimum.*

4. Moisture Absorption Less than 2%. Quinterra Type 71 resists humidity conditions that would break down other insulations. Even at high relative humidities, this new insulation exhibits its unusually high dielectric strength!

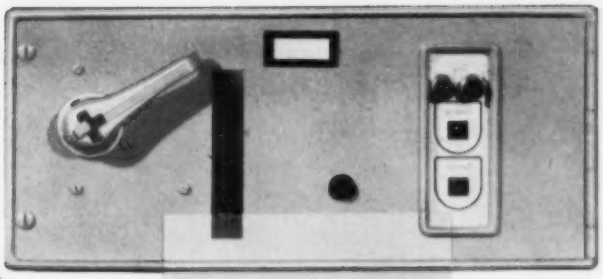
5. Improved handling characteristics make Type 71 Quinterra ideal for today's assembly techniques. Its flexibility lets it adapt to the reduced radii of smaller equipment.

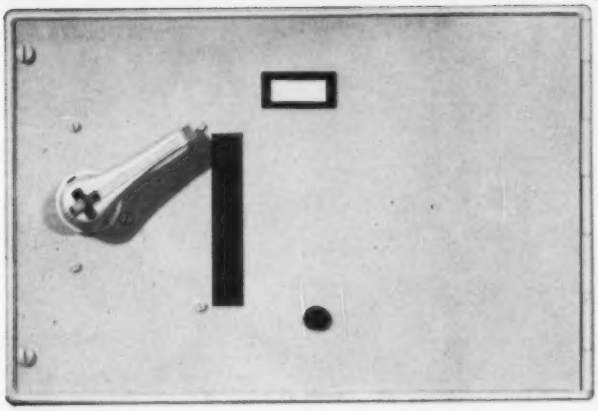
Also new Type 72 Quinterra for less rigid requirements

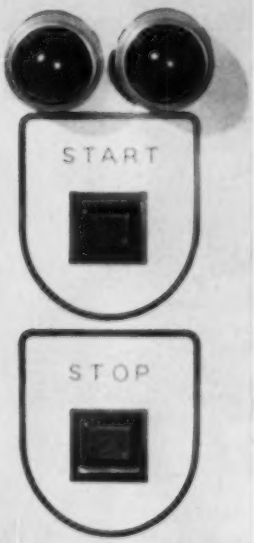
Type 72 Quinterra (approx. 20%-30% epoxy content) offers high dielectric strength at considerable savings.

FOR a complete specification sheet and samples of the new epoxy-treated Quinterra, write Johns-Manville, Box 14, New York 16, N.Y. In Canada, Port Credit, Ontario.

Johns-Manville ELECTRICAL INSULATIONS







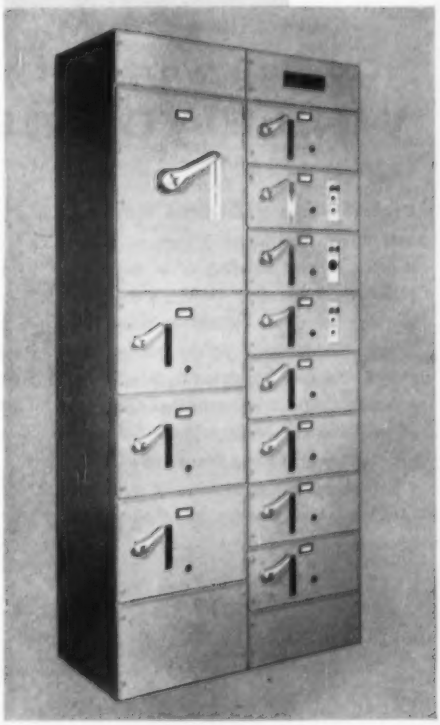
Announcing: NEW Westinghouse 14- and 9⅓-inch modular units for additional versatility

Complete Interchangeability Plus New Safety Features Mark Industry's Newest Control Center

The clean, efficient design of this new unit is the answer to today's—and tomorrow's—needs for complete flexibility in control center installations. Not only do you get the additional versatility of the new 9⅓-inch units, but also complete interchangeability with the old.

New safety features protect both personnel and equipment fully. Just as important as the dividends in installation, maintenance and safety are the moneysaving advantages of dealing with one source with complete responsibility for all your control center needs.

To learn more about the newest control center in the industry, call your Westinghouse sales engineer. Or, write Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-22043-A



YOU CAN BE SURE...IF IT'S

Westinghouse

Do you worry about plant expansion wiring costs
WHILE YOU'RE WAITING FOR A TRAIN?

If you're worrying about the costs of a new power distribution system — either in your present building or in that new plant you're planning — here's one way you can cut down on the worrying. Just specify Rockbestos A.V.C. (asbestos, varnished cambric insulated*) Interlocked Armored Cable. It will not only assure you of dependable service but will help you cut costs several ways. Here's how:

- Rockbestos A.V.C. Interlocked Armored Cable eliminates the need for costly conduits or ducts — it's easily installed on racks or hangers.
- Less layout time — less installation time mean important dollar savings.
- It permits planning for future installations — again at minimum cost.

Add to these direct cost-cutting advantages the long range economy of using a cable that gives you high current carrying capacity, that keeps maintenance at an absolute minimum and you can see the big savings possible when you specify and use Rockbestos A.V.C. Interlocked Armored Cable.

Get full details on dollar saving Rockbestos A.V.C. Interlocked Armored Cable — write now for complete specification and application data.

*Single conductors are N.E.C. type AVA

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The heart of this QMB Saflex Distribution Panelboard is the quick-make, quick-break, horsepower rated switch unit.

It's loaded with features—

- Each switch unit individually enclosed in heavy gauge steel
- Dead front construction
- Heavy duty cast operating handle
- Double-spring mechanism insures positive opening under full load
- Visible blades for maximum safety
- Positive pressure fuse clips and switch jaws assure maintenance-free connections
- Cover interlock prevents unauthorized access but makes normal maintenance easier

QMB Saflex Distribution Panelboard

Here's a panelboard that's built for the tough jobs! But it goes a lot further than rugged construction. It's designed with plenty of space for easier wiring and maintenance.

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SQUARE D COMPANY

NEW High-Frequency "X-Y" Oscilloscope for CURVE-TRACING Applications

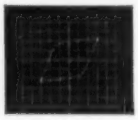
Now you can apply familiar techniques to today's high-frequency problems

Identical wide-band horizontal and vertical deflection systems in the new Tektronix Type 536 Oscilloscope open the way to accurate measurements and observations far beyond the previous limits, especially in curve-tracing applications. Any of the eight available Type 53/54 Plug-In Preamplifiers can be used in both deflection systems, making this instrument useful over an extremely wide range of applications. For instance, Type 53/54G Units with differential input eliminate the need for a common X Y terminal... a necessary condition for accuracy in many cases.

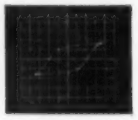
Uniform phase-shift characteristics of the main amplifiers and Type 53/54 Plug-In Preamplifiers assure negligible phase difference between the horizontal and vertical systems. With Type 53/54G Units the relative phase difference is less than one degree from dc to 15 mc, and phase balance can be obtained at any one frequency to above 25 mc. Although the 3db loss point occurs at 10 mc, five divisions of deflection can be obtained at 20 mc without overdriving the input amplifiers.

The Type 536 is also an excellent general-purpose laboratory oscilloscope. A new plug-in time-base generator, Type 53/54T, provides the horizontal deflection system with a wide range of sweep rates and extremely versatile triggering facilities.

Ferrite bead characteristics at two different temperatures. These B-H curves were plotted on the Type 536 Oscilloscope with wide band differential plug-in units. Driving frequency was *1 megacycle!* This is but one of the many unique uses for this instrument.



A. At 25° C.



B. Hot (equilibrium temperature due to self-heating).

PARTIAL LIST OF APPLICATIONS FOR A HIGH-FREQUENCY "X-Y" OSCILLOSCOPE

1. Examination of semiconductor diode characteristics — volts vs amperes plot.
2. Determination of B-H loops of ferromagnetic materials.
3. Linear amplifier distortion measurement.
4. Limiting or expanding-amplifier performance measurements.
5. Displaying pressure vs volume diagrams.
6. Analyzing amplitude selector type circuits such as Schmidt, diode pick-off, etc.
7. Checking regulated power supply performance.
8. Measurement of voltage coefficient of resistors.
9. Performance tests of various modulation systems such as AM, suppressed carrier, FM, PTM, PAM, etc.
10. Performance tests of demodulators for above modulation systems.
11. Determination of various gating circuit characteristics.
12. Function generator — $y = f(x)$.

TYPE 536 CHARACTERISTICS

VERTICAL and HORIZONTAL DEFLECTION SYSTEMS, with Type 53/54G Units plugged in —

Passbands — dc to 10 mc.
Risetimes — 0.035 μsec.

Deflection factors — 0.05 v/div maximum, 9 calibrated steps from 0.05 v/div to 20 v/div; continuously-variable adjustment between steps.

Relative phase shift — less than 1 degree to 15 mc, less than 2 degrees to 17 mc, less than 5 degrees to 23 mc — provided amplifiers are not overdriven by the input signals.

Amplifier phasing control — phase balance can be obtained at any one frequency to above 25 mc provided amplifiers are not overdriven by the input signals.

Linear deflection — 10 by 10 divisions (3⅛" x 3⅛").

Differential Input

HORIZONTAL DEFLECTION SYSTEM, with a Type 53/54T Time-Base Unit plugged in —

Sweep range — 0.2 μsec/div to 2 sec/div in 22 calibrated steps, with variable control for continuous adjustment from 0.2 μsec/div to 6 sec/div.

Magnifier — 5 x, accurate at all sweep rates.

Triggering — from external source, line voltage, or from vertical signal through front-panel connector, ac or dc-coupled, fully automatic triggering, amplitude-level selection with preset or manual stability control, and high-frequency sync.

Unblanking — dc-coupled to maintain uniform crt-grid bias for all sweep and repetition rates.

OTHER FEATURES

Voltage calibrator — square wave, 18 steps from 0.2 millivolts to 100 volts, frequency about 1 kc.

Electronically-regulated power supplies.

4-KV accelerating potential on new Tektronix crt.

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Type 536
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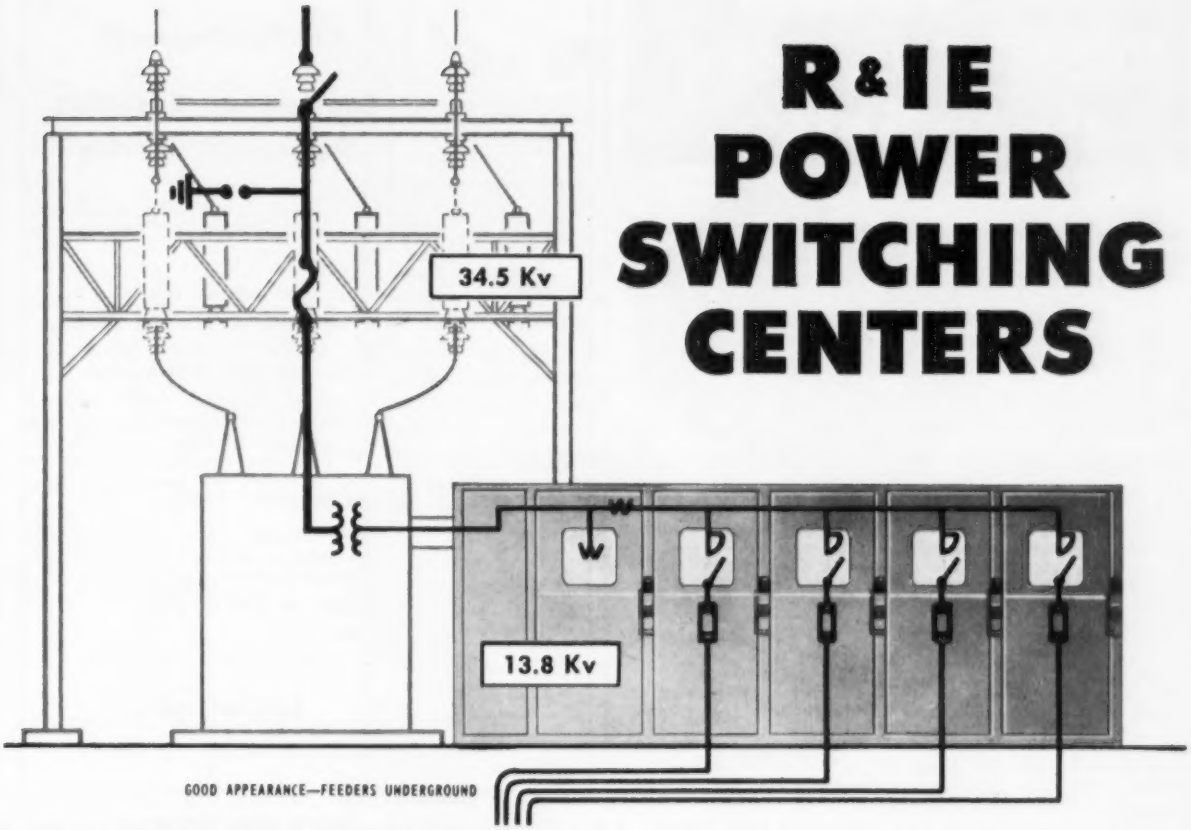
SEE THE TYPE 536 AND OTHER NEW TEKTRONIX INSTRUMENTS AT N.E.C. BOOTHS 192-193.

R&IE POWER SWITCHING CENTERS



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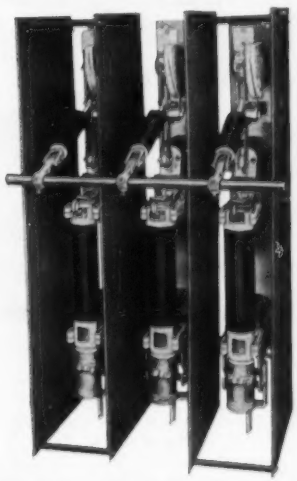

FUSED HPL-C INTERRUPTER SWITCHES

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600 Amperes—(40,000 amps. momentary)
1200 Amperes—(60,000 amps. momentary)

HIGH VOLTAGE PSC CUBICLES, standard design—offer three-way economy for primary switching when space is limited, cost is a factor and where feeders are underground.

CONSERVE SPACE—Less area required than with open structure. Standard PSC cubicles mean space requirements can be accurately determined. Add a cubicle any time—up to 1200 amp. total load.

SAVE MONEY—R&IE fused interrupter switches, in PSC cubicles, provide a high degree of protection. High interrupting capacity at moderate cost.

REDUCE MAINTENANCE PROBLEMS—Easily operated; window front inspection; equipment accessible; universally-known power fuses. Can be handled by any factory or building maintenance crew.

Add safety with optional TOG-L SNAP operating mechanisms.

Ask your I-T-E Representative to show you the many economies of PSC cubicles.

R&IE

R&IE EQUIPMENT DIVISION
I-T-E CIRCUIT BREAKER CO.
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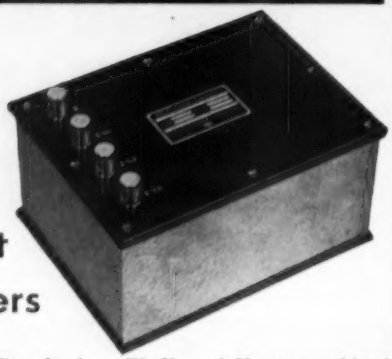
PSC • 4

You can rely upon KNOPP Standard Burden Sets...

when testing instrument transformers



The Knopp Standard Burden Sets offer burdens of reliable accuracy and stability and burdens that possess a freedom from stray fields and harmonics.

Type BSC-5 provides in one unit all three ASA standard burdens for current transformers for metering service, i.e., B-0.1, B-0.2, and B-0.5. For potential transformers (120-v secondaries), two sets are offered. The three burdens, W, X, and Y, are combined in Type BSP-6; and the standard burden Z is supplied in Type BSP-7, two of which can be used in parallel to obtain ASA burden ZZ. Accuracy of resistance and inductance values within 0.5 per cent.

For full details about the Knopp Standard Burden Sets, write today.

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Radio Engineering Products is currently producing a number of types of equipment, electrically and mechanically interchangeable with standard Bell System apparatus.

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CARRIER-TELEGRAPH EQUIPMENT

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VOICE-FREQUENCY EQUIPMENT

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D-C TELEGRAPH EQUIPMENT

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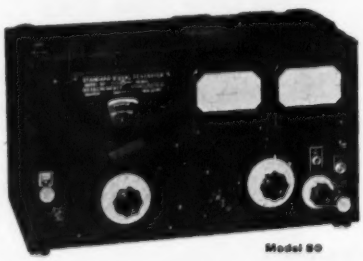

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GENERAL SYSTEM

Your job: find the one in 60 million

Direct distance dialing is the telephone industry's term for the comparatively recent introduction of dialing your long distance calls direct, instead of placing them through an operator.

Many electro-mechanical engineers at General Telephone Laboratories are working on the intricate and fascinating problems that continually arise in this particular phase of telephony.

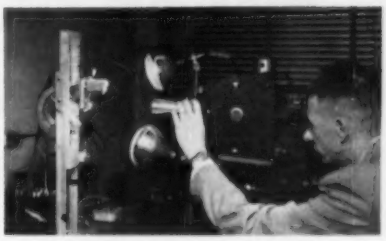
To get an idea of the complexity of these projects, try to picture the telephone network of this country as a single, integrated machine consisting of about 60 million telephones. Then consider the task of connecting any one of these telephones to any other simply by dialing from ten to thirteen digits, instead of the conventional seven digits for local calls.

Remember that the connection must be made as quickly as it is in dialing your next door neighbor—and, of course, with the unfailing accuracy the public takes for granted in their dial telephone. Now you begin to comprehend the complex circuitry and high-speed switching that are the province of the telephone engineer.

Although direct distance dialing is a reality of some years standing in many parts of the country, not all the problems have been threshed out by a long shot. New detection methods are being investigated. Systems that work faster and take less space are the constant goal. And, as with every innovation in telephony, the problem of converting existing systems to handle the latest miracle is the telephone engineer's never-ending challenge.

The dial—automation's granddaddy

While the telephone industry did not invent the term automation, it did invent most of the processes and products that have made automation possible.



Filming high-speed rotary switches to study operations in slow motion.

For instance, the invention of the dial telephone by Automatic Electric engineers (that was 1892, believe it or not) led directly to automated assembly lines, automatic pin spotters, digital computers . . . you name it.

Automatic Electric is one of our affiliated manufacturing companies in the General Telephone System. For generations it has been a leading source of control components for industry as well as the principal equipment manufacturer for independent (non-Bell) telephone companies. And General Telephone Laboratories provide R&D support for the entire sphere of Automatic Electric's widely diversified manufacturing operations and for all of the other manufacturing and telephone operating companies in the General Telephone System.

You're invited . . .

The tremendous growth in the communications industry specifically and in the application of automation principles in general have created many stimulating new engineering opportunities here at General Telephone Laboratories. We're interested in you if you are qualified for important research and development work in electronics, electrical, electromechanical or mechanical engineering, or physics.

We can be much more specific about your particular career destinations if you will write directly to Mr. Robert Wopat, president, General Telephone Laboratories, Northlake, Illinois.

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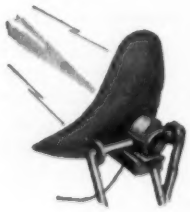

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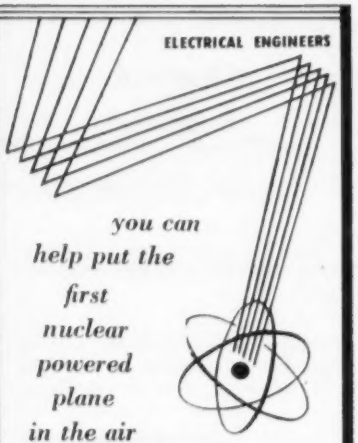

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at the AIRCRAFT NUCLEAR PROPULSION DEPARTMENT OF GENERAL ELECTRIC

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Two weekly bulletins of engineering positions open, one covering positions on the Pacific Coast and the other covering Midwestern and East Coast positions, are published and each is available to members at a subscription rate of $3.50 per quarter or $12.00 per annum, and to nonmembers at $4.50 per quarter or $14.00 per annum.

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MANAGER OR SUPVR, B.S.E.E., M.S.E.E.; age 29; 9 yrs product devpmt in electrical controls involving semiconductors, tubes and electro-mech servos. Supervisory exper in directing efforts of res and devpmt minded engrs. Location desired: New York, Chicago, San Francisco. E-911.

ASST TO PLANT MGR OR ADMIN ENGR, grad 1947; age 35; 13 yrs varied exper in elec industry. Considerable supervisory exper. A nonconformist who gets things done now. Location desired: United States. E-912-823-Chicago.

MANAGEMENT ENGR, B.S.E.E.; age 37; 16 yrs broad exper in pwr and comm engrg and considerable exper in civil and mech engrg fields with a major integrated oil company in Venezuela. Exper also includes admin and staff work as well as training for management. Location desired: South or Southwest. E-913.

ELEC ENGR, B.S. Univ of Cal; age 28; 5 yrs exper with large smelting and refining co. Maint, opern and installation of indus eqpt, substations, distr lines, rectifiers, electric furnaces. Knows Spanish and has ability for training and supervising large native crews. Location desired: Foreign, Latin America. E-914.

PLANT OR PROD ENGR, B.E.E.; age 30; 4½ yrs project engr on lighting, pwr distr, maint problems and spec writing; 1½ yrs constr engr on bldgs, piping, road and elec projects. Developed and taught basic electronics course. Location desired: New England. E-915.

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ELECTRONICS ENGINEER, M.S. preferred, for wind tunnel research in fluid mechanics and microclimatology. University research projects in cooperation with Federal agency. Program is designed to develop an engineer capable of solving unique and difficult electrical instrumentation problems in fluid mechanics. If applicant holds a B.S. can study for M.S. in E.E. and Ph.D. in fluid mechanics. Can study for Ph.D. in fluid mechanics with M.S. Location, West. W-4980.

ENGINEERS. (a) Head, Government Research and Development, 30-35, M.S.E.E., to direct activities of an R & D group of 10 engineers engaged in advance technical activities in diverse fields related to data processing. Should have five to ten years' experience in advanced R & D work aimed at government use. Salary, $11,000-$14,000 a year. (b) Head, Product Planning Section, M.S. or equivalent electronics engineer, to evaluate need of technical systems in company's field of interest; oppose and specify new products compatible with those systems. Should have experience in system analysis, development work, mathematics, seven to ten years. Knowledge of data handling techniques required. Salary, $10,500-$12,000 a year. (c) Electronic Engineer, Applications and Projects Group, B.S.E.E. degree, with a minimum of three years' practical experience in electronic circuit and equipment design and development including one year in pulse techniques and one year's experience demonstrating ability and capacity to plan, supervise, organize and coordinate technical work. Will work with conversion of telemetry signals from analog to digital form; set up format for digital tape, card punch and paper tape computer, input devices, etc. Salary, $7500-$9000 a year. Location, central New Jersey. W-4996.

MARKETING MANAGER, electrical graduate, plus M.S. preferably marketing major, to head up merchandising of electronic test and measuring equipment, analog computers and aircraft instruments. Salary open. Location, Pacific Coast. W-5073.

ELECTRICAL ENGINEER, bachelor's degree, with two to five years' experience. Design, specification, procurement, power distribution systems and equipment, lighting controls, motors, generators. Design and construction experience required. Power plant experience desirable. Company offers liberal pension, insurance and hospitalization plans. Apply by longhand stating education, year and college at which degree was earned, experience, marital and military service status, availability, present salary, two references. Location, Florida. W-5088.

TEACHING PERSONNEL for Department of Electrical Engineering. Positions available for assistant or associate professors. For individual having proper qualifications, the opportunity will exist for assuming position of Head of Department; full professorship would accompany this position. Salaries open. Location, New England. W-5096.

NOTE

Be sure to address all Personnel Service box numbers to Box _____

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ENGINEERS for an electronics company. (a) Junior Engineer, B.S.E.E. or B.S.M.E., with none to one year's experience on design of electronic or electro-mechanical equipment with emphasis on communications gear. Will perform engineering studies, circuit development and test specifications. Salary, $6660 a year. (b) Engineer, B.S.E.E. or B.S.M.E., with three to five years' experience on complex electronic and electro-mechanical projects. Will plan and perform engineering studies, experimental investigation and design of electronic equipment (communication). Salary, to $9200 a year. Company will pay placement fees; interview expenses and relocation expenses. Location, Massachusetts. W-5102.

ENGINEERS for an electronics company. (a) Senior Engineer, B.S.E.E. or B.S.M.E., with five to seven years' experience on electronic projects. Will plan and perform engineering studies, experimental investigation on complex problems. May act as project leader on entire projects. Salary, to $11,000 a year. (b) Project Engineer, B.S. degree, with seven or more years' experience on designs, development and production of electronic and electro-mechanical equipment. Will coordinate, plan and direct all phases of various projects with engineering and manufacturing. Salary, to $13,000 a year. Company pays placement fees; interview expenses and relocation expenses. Location, Massachusetts. W-5103.

SUPERVISORY SYSTEM ENGINEER, registered professional electrical engineer, thoroughly experienced in planning construction and operating practices of electric transmission and distribution utilities. Previous experience in responsible positions is mandatory and demonstrated organizational ability is required. Public utility experience helpful. Salary open. Location, Alaska. W-5104.

TEACHING PERSONNEL for electrical engineering department: Instructors, Assistant or Associate Professors in power, communications or basic engineering courses. Applicants for Assistant or Associate Professor should have Master's degree in electrical engineering; teaching experience desirable but not essential. Salary, nine month basis: Instructors, $4200-$5300; Assistant Professor, $5300-$6500; Associate Professor, $6500-$7500. Available September, 1957. Location, New York State. W-5135.

SUPERVISOR, electrical section, engineering and construction department, graduate electrical, with extensive experience in industrial application of electric power; control and distribution systems; and the design, construction, installation, operation and testing of electrical equipment. Supervisory experience highly desirable. Under direction, will supervise activities of section engaged in research on materials and equipment, predominantly electrical in nature. Salary, from $12,000 a year. Company pays placement fee. Location, eastern Penna. W-5139.

ELECTRICAL ENGINEER, graduate, with from seven to ten years' of applicable experience, including some work in power distribution, application and rectification for work in general design and development group in central engineering organization handling new plant design and existing plant additions and modifications for primary metals industry. Salary open. Location, Pacific Coast. W-5145.

MANAGER, Engineering Standards and Specifications, B.S. degree, preferably in electrical, administrative, mechanical or industrial engineering, with a broad knowledge of the physical sciences and definite leanings toward administrative phase of an engineering operation. Minimum of five years' experience as a standards engineer with an electrical manufacturer, or employment in some technical capacity, with considerable knowledge of government specifications and standards. Background should include administrative or supervisory work. Must have a flair for writing. Will have direct administrative and technical supervisory responsibility for the performance of a group of standards engineers engaged in preparation and coordination of company specifications and standards, and the interpretation of government and commercial standards and specifications; will train less experienced personnel; will serve on Standards and Specifications Committee, etc. Salary, $8400-$9600 a year. Location, Ohio. W-5176.

(Continued on page 102A)

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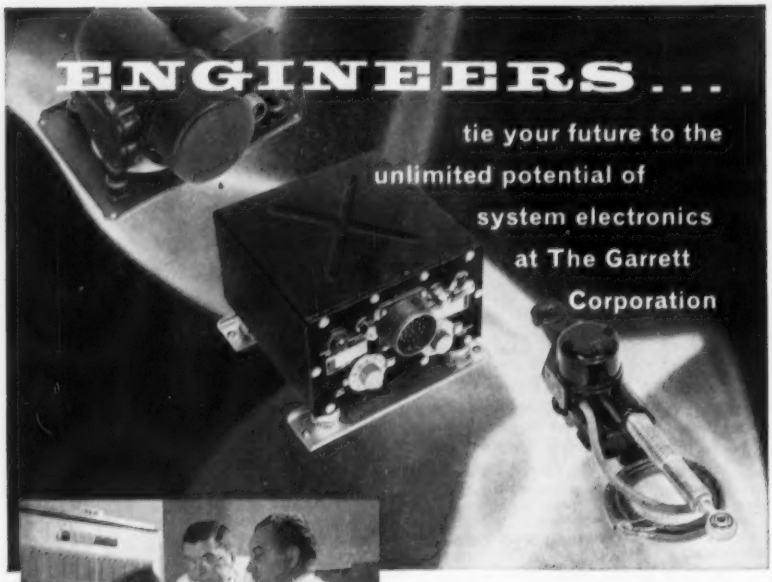

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- **OPERATIONAL ENGINEERS** Graduate engineers for follow-on development of the above mentioned product categories. This work includes such activities as: laboratory circuit development of breadboards and prototype hardware, specialized test equipment design and construction, liaison with design drafting group, liaison with customer during initial equipment installation in aircraft, engineering instruction writing for inspection and production departments, and additional engineering functions necessary for establishing efficient production of the equipment hardware.
- **COMPONENTS ENGINEERS** Graduate engineers to act as consultants in matters of vendor contact on electronic and electro-mechanical components. These positions require experience in component testing as on potentiometers, capacitors, etc., and a knowledge of relative qualities and state-of-the-art of such components as manufactured by various vendors. Familiarity with military aircraft specifications desirable.
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(Continued from page 100A)

Personnel Service, Inc.

DIRECTOR OF SYSTEMS PLANNING, graduate electrical, 34-38, with five or more years' experience in staff and/or line positions in a company whose primary interests are in or related to an electrical field of endeavor, for a utility. Will be responsible for determining the nature and extent of facilities and equipment required for servicing customers in the utility's area; will plan future growth, oversee purchase and installation of facilities and equipment, etc. Salary, $15,000 a year with additional benefits. Location, Midwest. W-5180.

CABLE SALES ENGINEER, 28-35, E.E., M.E. or Ch.E. degree or equivalent combination of training and experience, with at least three to five years' experience selling electrical multiconductor cables for a manufacturing organization. Similar or related internal experience in sales department of such a company acceptable. Should be executive calibre for potential sales management and administrative responsibilities. Some traveling required throughout the United States. Starting salary range, $8000-$9000 a year, plus travel expenses. Headquarters, New England. W-5192.

FACILITIES ENGINEER, B.S.E.E., with two years' electrical contracting or construction work, to perform electrical engineering and related work, including installation of production machinery and plant facilities equipment, etc. Salary, $6800-$8750 a year. Location, Midwest. W-5198(a).

ELECTRICAL INSTRUMENTATION ENGINEER, to 40, to do general plant electrical engineering and operate instrument shop. Will design moderately complicated instrument installations for chemical process plant. Salary, $7000-$9500 a year. Location, North Carolina. W-5206.

ELECTRICAL ENGINEERS. (a) Interference and Noise Engineer, electrical graduate, with background in RF field strength measurements, propagation characteristics from ULF through radar frequencies. All aspects of electronic interference and noise including evaluation, measurements and design improvements involving complete systems and/or unit equipment. Salary, $6000-$10,000 a year. (b) Systems Engineer, electrical graduate, with background in allocation and use of communications frequencies. Layout and design of specialized communication systems. Will need good theoretical background in use of above. Salary, $6000-$12,000 a year. (c) Research and Development Engineer, electrical graduate or equivalent experience, to work in R & D laboratory on theoretical and empirical development of circuits and devices of electronic, electro-mechanical or mechanical nature to fulfill specified requirements. Will initiate and supervise construction and testing of models and equipments to demonstrate practicality of developments. Will work under chief engineering supervisor as project head. Salary, $6000-$10,000 a year. Location, Washington, D.C. W-5220.

ELECTRICAL ENGINEER, preferably degree in electrical engineering, with a minimum of three to five years' previous experience in design of electro-mechanical mechanisms. Salary, to start, about $8000-$9000 a year. Location, Connecticut. W-5224(a).

SALES ENGINEER, 28-35, graduate electrical or mechanical, for small manufacturer of elevators. Experience in this field not required but should have to three years' experience in contacting architects and consultants. Salary, to $10,000 a year. Location, New York, N. Y. W-5247.

TEACHING PERSONNEL, graduate electrical engineers. Excellent opportunities available to teach electrical engineering in new department. Salaries, rank and teaching opportunities excellent. Appointments available starting September, 1957. Medium size university in Illinois. C-6374.

DESIGNER, electrical wiring, electrical graduate or equivalent, with five to seven years' experience in industrial wiring and control and knowledge of automatic controls desired. Salary, about $8400 a year. Location, San Francisco, Cal. S-3007.

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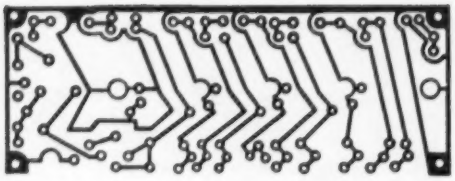

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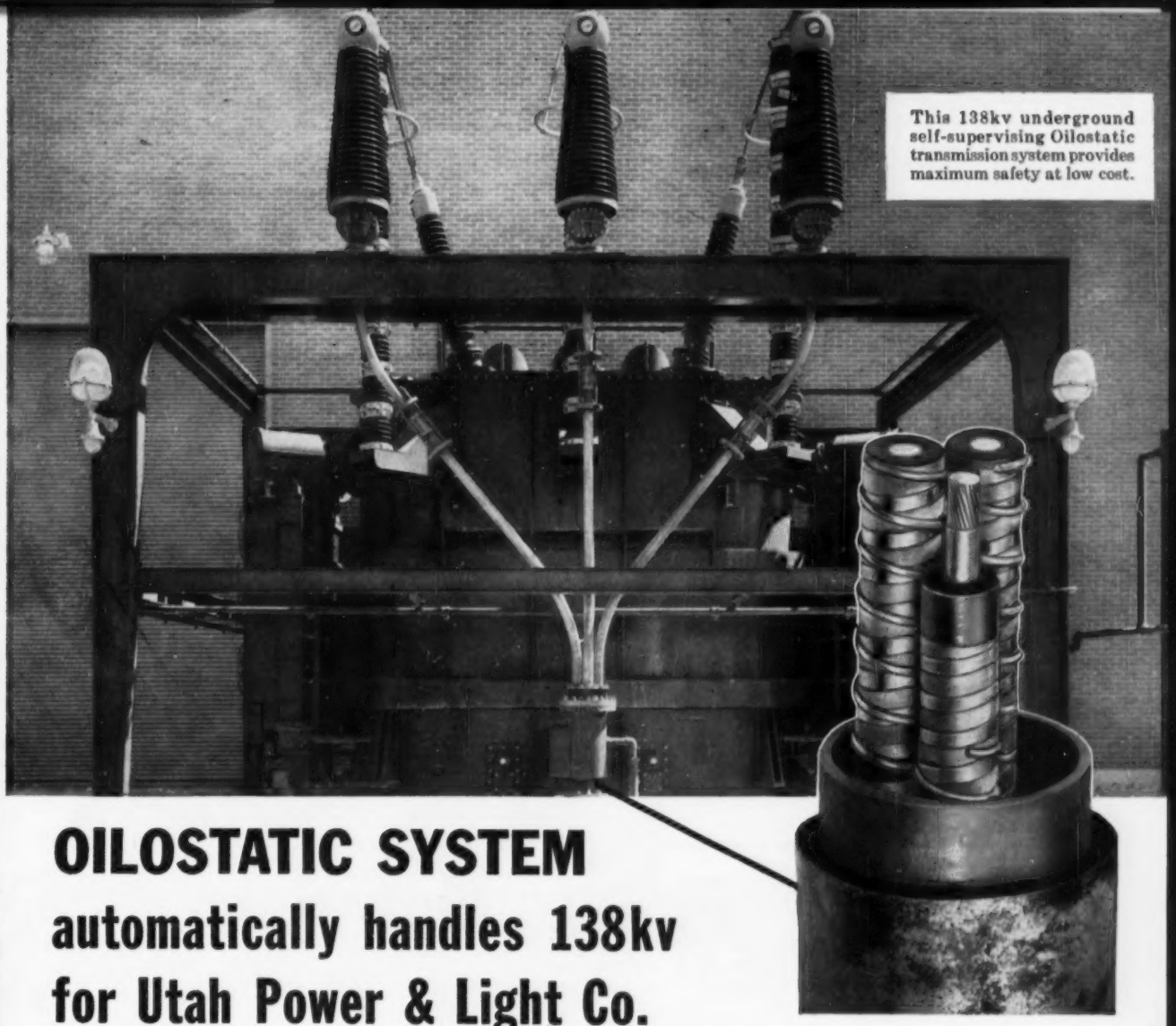

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available with either copper or aluminum conductors

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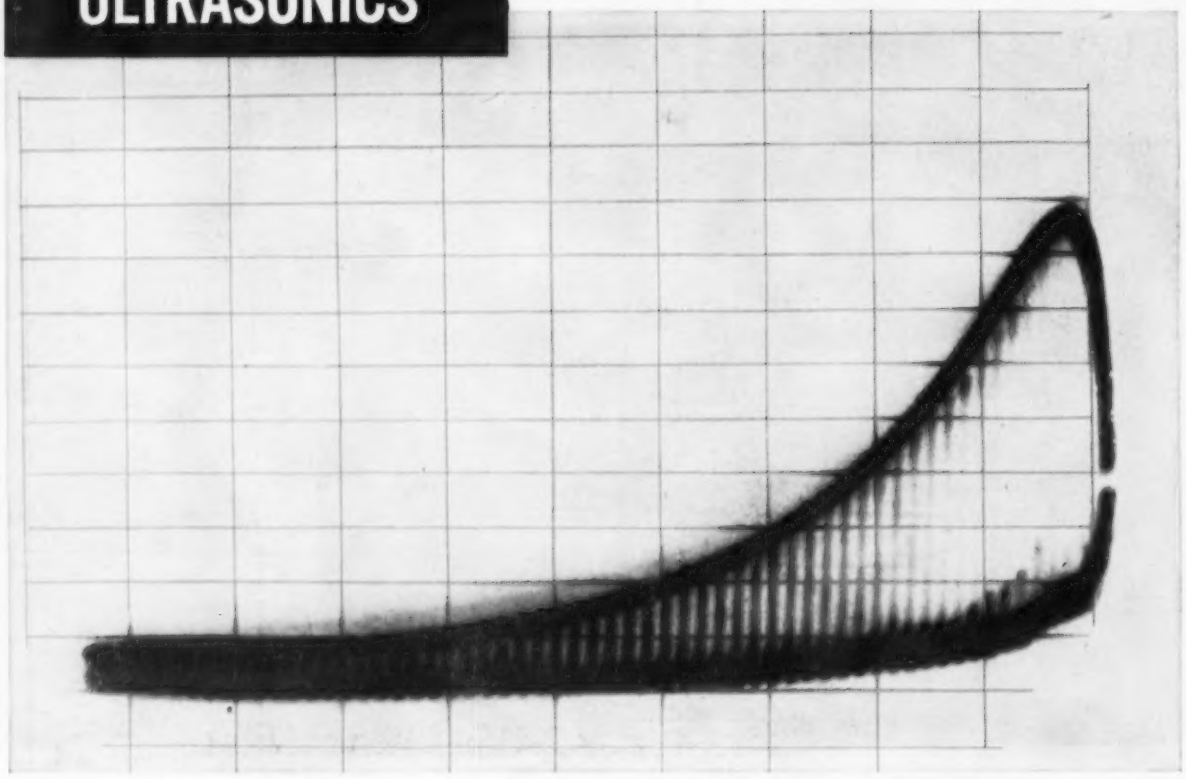

Attenuation trace of Zircaloy structural component with ultrasonic pulser operating at five megacycles.

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Ultrasonics is employed as a new inspection technique by electrical engineers at Bettis Atomic Power Division for the non-destructive testing of materials for nuclear power plants. In this context, ultrasonics refers to complex electrical equipment, such as high frequency pulsing circuitry, video circuits, and facsimile recording used to produce and detect sonic vibrations.

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Challenging opportunities at Bettis Atomic Power Division include instrumentation, control systems and electrical apparatus for nuclear power plants. We welcome inquiries from electrical engineers interested in the excellent careers offered by one of the leaders in the new and growing nuclear power industry. Please send your résumé to: Mr. M. J. Downey, Bettis Atomic Power Division, Westinghouse Electric Corporation, Box 1468, Department A-191, Pittsburgh 30, Pennsylvania.

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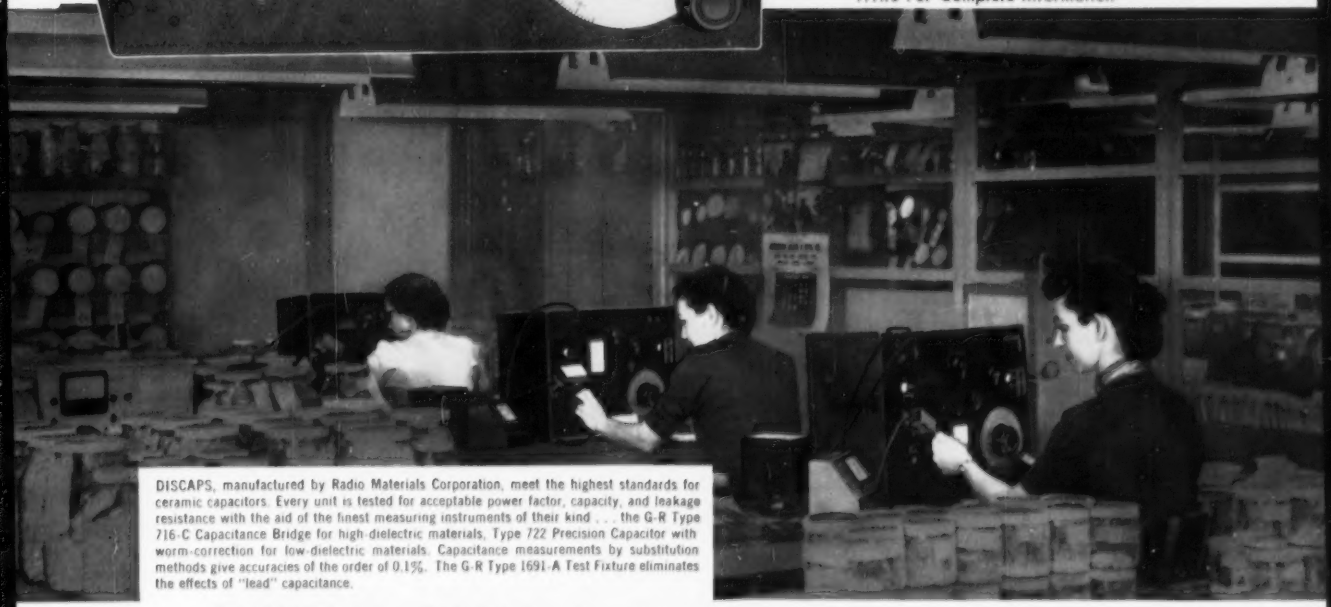

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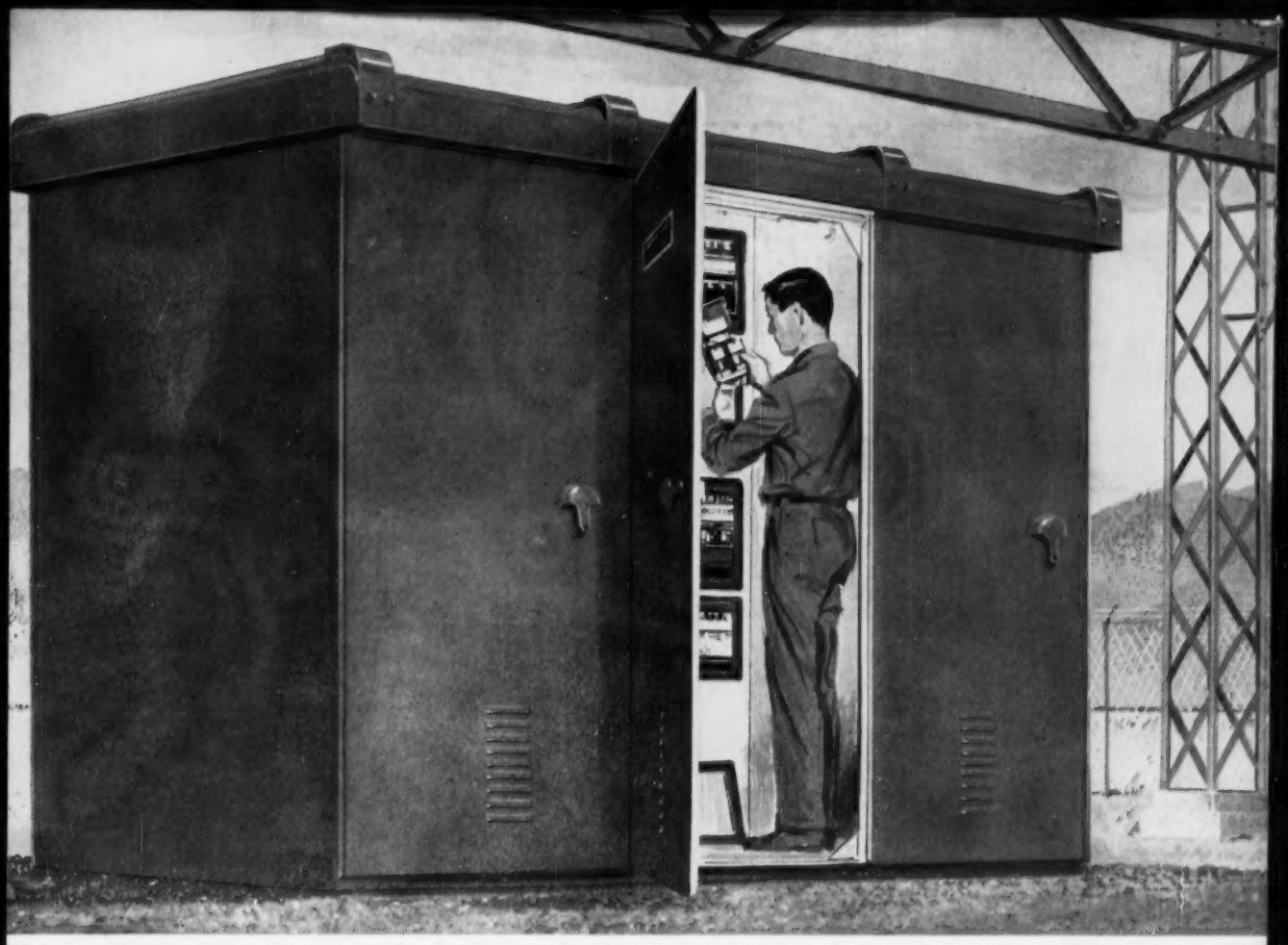

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